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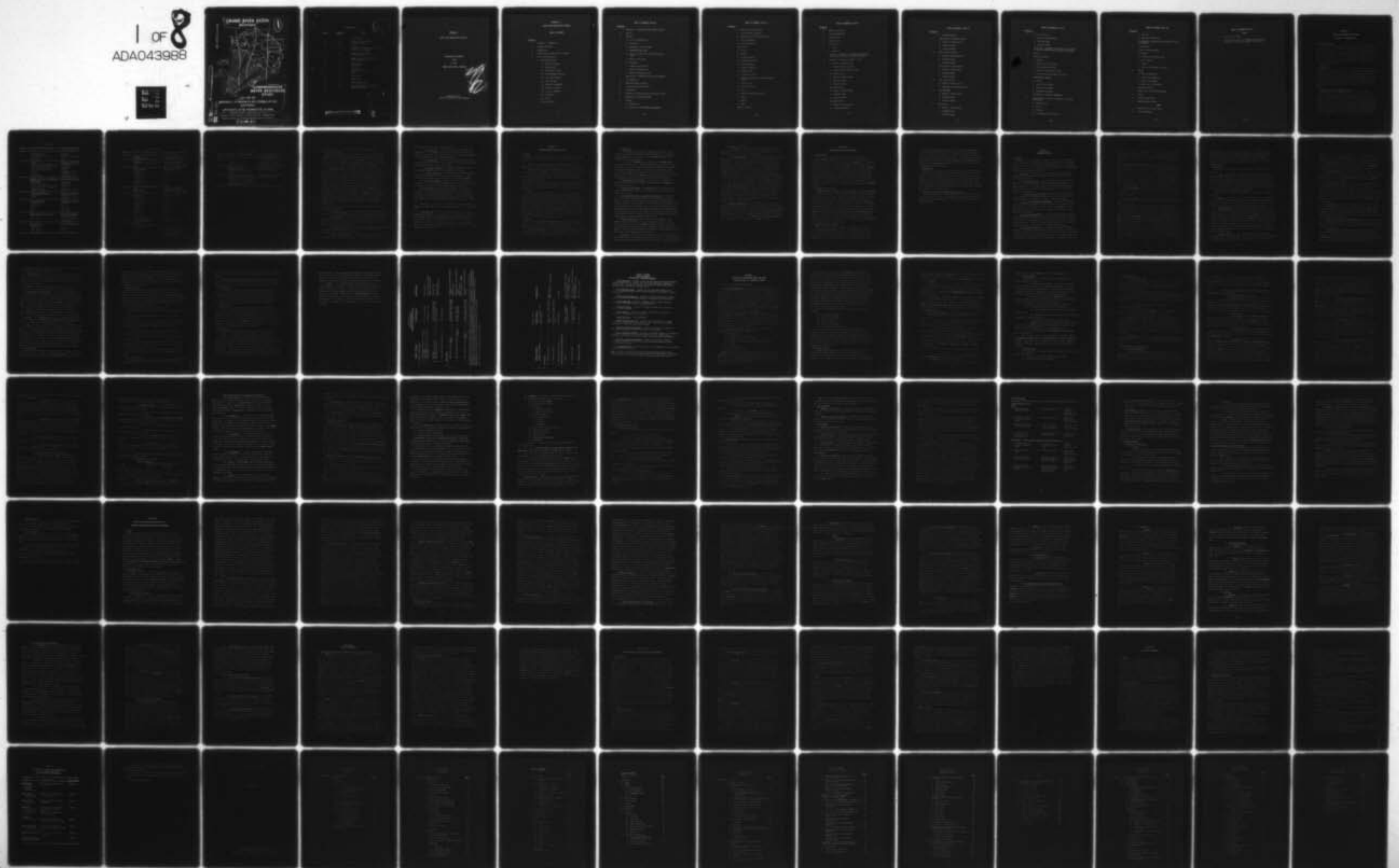

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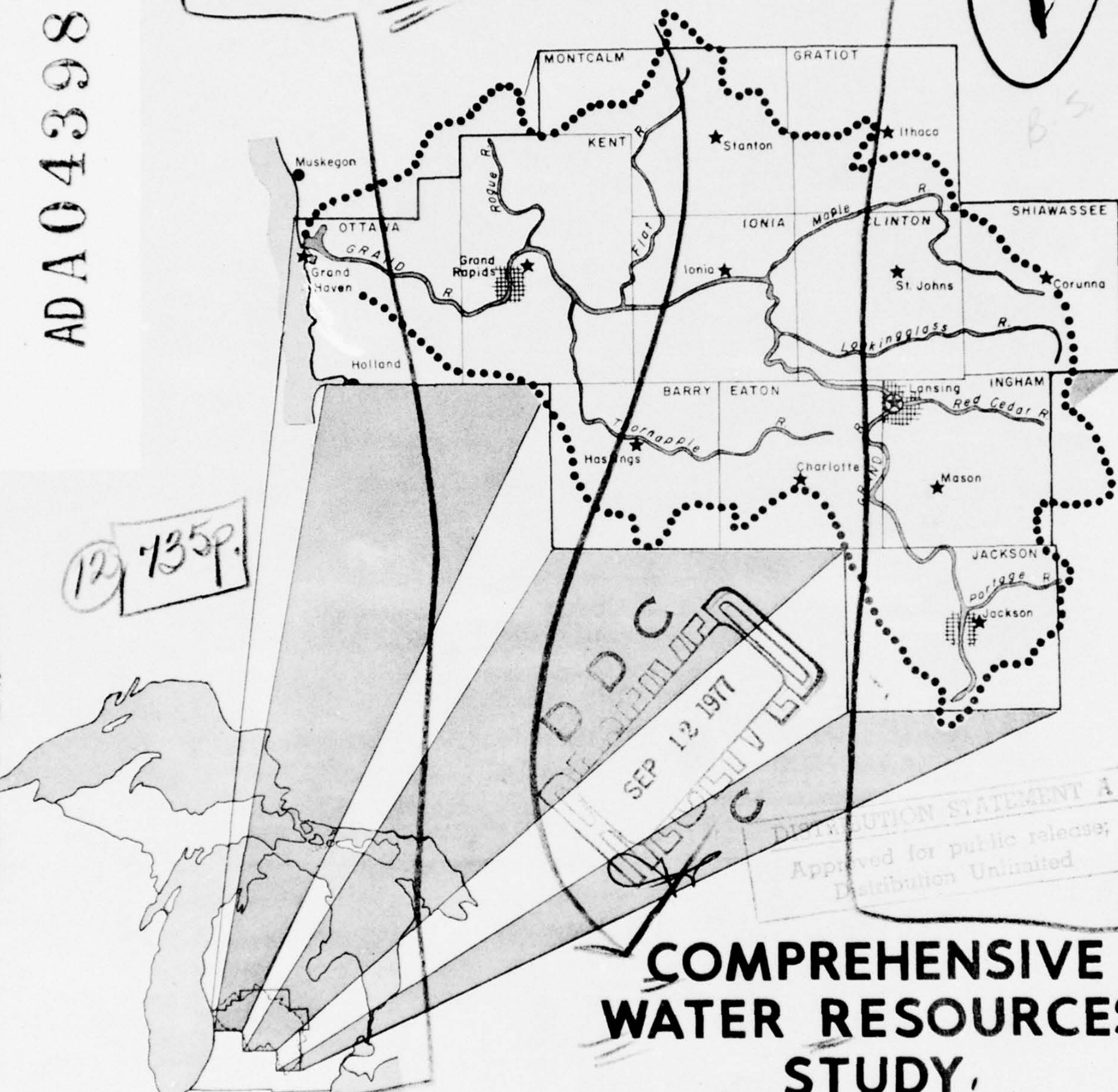

COMPREHENSIVE WATER RESOURCES STUDY

VOLUME XI

APPENDIX P—BASIN PLAN FORMULATION CRITERIA

APPENDIX Q—ALTERNATIVE PLANS

Prepared Under Supervision of the
GRAND RIVER BASIN COORDINATING COMMITTEE
Chairmanship: U. S. Army Engineer District, Detroit

AUGUST 1973

VOLUME INDEX

Volume	Appendix	Title
I		Main Report
II	A	History of Investigation
	B	Basin Description
III	C	Climate
	D	Surface Water Hydrology and Hydraulics and Fluvial Sediment
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	F	Mineral Resources
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APPENDIX P

BASIN PLAN FORMULATION CRITERIA

COMPREHENSIVE PLANNING

STUDY

OF THE

GRAND RIVER BASIN, MICHIGAN

Prepared by the
Basin Plan Formulation Subcommittee

APPENDIX P

BASIN PLAN FORMULATION CRITERIA

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APPENDIX P

BASIN PLAN FORMULATION CRITERIA

SECTION I - INTRODUCTION

1. PURPOSE AND SCOPE

The purpose of this appendix is to explicitly state the criteria that will be used in formulating the Basin Plan. Scope of the criteria will be sufficiently broad so as to be useful in selecting, designing, evaluating, and justifying alternative solutions for development of the Plan and the comparing and selecting the optimum mix and scale of projects to be included in the Plan. However, the scope will not be so broad that it encompasses developments and plans that are not relevant to formulation of the Plan.

2. ASSUMPTIONS

Assumptions that will be used in stating these criteria vary considerably in scope and origin and cannot be generalized. As the various criteria are discussed below, relevant qualifying assumptions will be stated, so that in the event the assumptions become obsolete, the need for changes and the extent of their impact will be apparent. Preservation and beautification considerations should be included in plan formulation and thoughts on this are introduced in Section 11 of this appendix.

3. RELATIONSHIP TO OTHER PARTS OF REPORT

This appendix and the criteria contained herein constitute an underlying philosophical base to the entire Basin Plan. Thus, all parts of the report and most of the accompanying appendices, with the exception of pure physical and factual data, are predicated upon these criteria. Even such data are, to some extent, interrelated with these criteria, since they are implicitly present in the data collection and screening process. Table P-1 summarizes resources and planning items found in each appendix and also states the agreed units of measurement to be considered. Thus, there is a direct relationship between the

TABLE P-1

Appendix	Resources and Planning Items	Topic Designation and Units of Measure
B	Basin Description	Narrative
	Inventory of Facilities	Geographical Location
	Water Areas	Acres
	Land Areas	Acres
C	Climate	Geographical Variation
	Temp. (Normal & Extremes)	Degrees F/Time
	Precipitation (Normal & Extremes)	Inches/Time
	Frost-free Growing Season	Days/Year
	Wind (Normal & Extremes)	MPH/Time
	Humidity	% Relative Hum/Time
	Fog	Days/Year
	Cloudiness	% Possible Sunshine
	Frozen Ground	Depth/Time
D	Surface Water Hyd. & Hydraulics & Fluvial Sed.	Geographical Location
	Runoff Volume	$AF/Year/Mi^2$
	Annual Hydrograph	$Q/Mi^2/Time$
	Mass Curve & Stor. Yield Analysis	$Q/Mi^2/Time$
	Low & High Flows & Frequency	Q/Time
	Fluvial Sediment	Accumulation AF/Time
	Suspended Sediment	P.P.M.
E	Geology and Ground Water	Geographical Location
	Availability	G.P.M or C.F.S.
	Quality	Biological, Chemical, Thermal
F	Mineral Resources	Geographical Location
	Sand and Gravel	Short Tons
	Natural Gas	M. cu. Ft.
	Petroleum	Bbl.
	Stone	Short Tons
	Peat	Short Tons
	Clay	Short Tons
G	Water Use and Stream Quality	Geographical Location
	Water Supply	M. Gal./Day/Time or C.F.S./Day/Time
	Water Quality	Biological, Chemical, Thermal, Etc.
H	Flood Control	Geographical Location
	Reservoir Sites	
	Water Area	Acres
	Water Volume	Acre-Feet
	Land Area	Acres
	Local Protection	Acres Protected

TABLE P-I (Cont'd)

Appendix	Resources and Planning Items	Topic Designation and Units of Measure
I	Navigation	Geographical Location
	Navigable Streams	Miles of River
J	Recreation	Geographical Location
	Existing, Programmed, Potential	Visitor-day/Resource Class
	Water	Acres and Acreage Capacity
	Land	Acres and Acreage Capacity
K	Fish and Wildlife	Geographical Location
	Existing	
	Sport fishing	User-days
	Hunting	User-days
	Planned	
	Sport fishing	User-days
	Hunting	User-days
	Management Areas	
	Existing	Acres
	Planned	Acres
	Rare and Endangered Species	Number
L	Power	Geographical Location
	Hydroelectric	Capacity (KW and Load Factor)
	Steam Generated	Capacity (KW and Load Factor)
M	Agriculture	Geographical Location
	Upstream Reservoir Sites	
	Water Area	Acres
	Water Volume	Acre-Feet
	Land Area	Acres
	Land and Water Area	
	Water Area	Acres
	Urban Land	Acres
	Cropland	Acres
	Pasture	Acres Land Potential
	Forest Land	Acres
	Other	
	Public Land	Acres
	Land Stabilization	Acres or Miles
	Land Drainage	Acres
	Watershed Management	Acres
N	Water Laws	
	State and Federal Water Laws, Policies, Procedures and Organization	Agencies involved in Research, Planning, Design and Construction, Water and Land Development
	State	State and Respective Agencies, Watershed Council

TABLE P-I (Cont'd)

Appendix	Resources and Planning Items	Topic Designation and Units of Measure
N (Cont'd)	Local	Regional Commissions, Counties, Cities
	Private	Corporations, Companies Profit-Making Organizations
	Enabling Legislation	Laws, Policies, Procedures
O	Economic Base Study	Geographical Location
	Projections of Population, Employment, Production, and Land Use	Persons - Acres
P	Basin Plan Formulation Criteria	Geographical Location
	Planning Policies and Procedures, Planning Criteria, Criteria for Determining Water and Land Resources Needs, and Structural and Nonstructural Methods	Persons - Acres

criteria and most parts of the summary report and its appendices.

4. BASIN PLAN OBJECTIVES

General. The objective of this comprehensive study is to formulate a plan for the development of the Basin's water and related land resources that will provide for the best use, or combination of uses of these resources to meet all foreseeable short and long term needs and to determine the best means to accomplish this development in a timely manner.

a. Intermediate Goals. In order to translate this objective into practical working criteria that can be used in the project formulation process, it is first necessary to develop intermediate goals. In a basin where water resources development is limited and its potential can be regarded as a scarce commodity not all of the intermediate goals can be achieved. Thus, the competition among uses for resource developments requires comparisions of the social and economic benefits and costs for alternative development schemes that place emphasis on the various uses. In making such comparisions, it is imperative that all tangible and intangible benefits and costs relevant to the overall objective be given due consideration. Since the establishment of arbitrary priorities which are not relevant to the objectives violates the desired principles outlined above, such practices will be avoided unless some overriding objective (such as national security, or protection of public health) requires them.

Briefly, the intermediate goals of this study are to develop project plans for the following:

(1) Adequate supplies. To provide adequate municipal, industrial, agricultural, and domestic water supplies to accommodate anticipated growth.

(2) Water quality. To provide water quality controls and pollution abatement facilities so that the basic objective of providing for the best possible combination of water uses to meet reasonable needs will not be impaired by controllable waste inputs.

(3) Hydroelectric power. To provide for development of hydroelectric power where potential exists, projects are economically feasible, and reasonable other uses are not unduly impaired.

(4) Flood damage prevention. To provide flood control and flood prevention measures where they are desired, economically feasible, and

reasonable other uses are not unduly impaired.

(5) Land treatment. To provide for use of land within its capabilities, and treatment, with practical limits, according to the chosen use to prevent further deterioration of soil and water resources. It can include structural stabilization measures.

(6) Land drainage. To provide land drainage measures, both urban and agricultural, where they are needed, economically feasible and reasonable other uses are not unduly impaired.

(7) Watershed management. To provide watershed protection measures and management where they are desired and needed.

(8) Outdoor recreation. To provide outdoor recreation opportunities, where feasible, in areas with identified needs at a level consistent with general social and cultural requirement standards.

(9) Fish and wildlife. To provide for the conservation and development of fish and wildife resources where feasible and at a level consistent with identified present and projected future needs.

(10) Navigation. To provide for navigation facilities which are beneficial and economically feasible additions to the Nation's transportation system, including recreational navigation improvements consistent with the increasing recreation needs of the Nation, taking into consideration other values which may be destroyed by such construction.

(11) Other. To provide any other means by which development of water and related land resources will promote economic growth and development.

b. Long Term Goals. To provide long-term projections of economic development, translation of such projections into demands for water and related land resource uses, projection of water availability both as to quantity and quality, and projections of related land resources availability, so as to outline the characteristics of projected water and related land resource problems and the general approaches that appear appropriate for their solution.

SECTION II

PRESERVATION AND BEAUTIFICATION

1. GENERAL

The need is recognized for preservation and beautification in water and related land resource planning, and consideration should be given to:

a. Protection and rehabilitation of existing water and related land resources to insure their availability for best use when needed.

b. Maintenance and use of open spaces, green belts and areas adjacent to rivers, lakes and reservoirs for recreation and preservation purposes.

c. Preservation and management of areas of unique natural beauty, historical and/or scientific interest for the inspiration, enjoyment and education of the people.

The overriding determinant in selecting the best use is the well-being of the people. Whenever objectives conflict, resolution should be by reasoned choices, with full consideration of each objective and/or preservation element.

The projects and related elements, such as roads, visitor areas, and other elements which surround the project should be planned to be aesthetic assets to the Basin, State, and Nation. Beautification should be included as an integral part of the design of a project in the degree appropriate to each type of project and commensurate with its location and exposure to the public. The costs for such beautification measures should be included and identified as a regular project cost. Since it is inherently impossible to evaluate the magnitude of values associated with intrinsic beauty, recognition can only be provided through the consensus of value judgment of the planners involved.

2. SPECIFIC

With regard to design of any particular water resource project, the following are suggestions of aesthetic treatment relating to some specific construction elements, but not limited to those listed below.

a. Public Accommodations. The following facilities shall be provided for public use, where appropriate: (1) drinking water; (2) toilets; (3) trash and rubbish disposal; and (4) water craft waste disposal.

b. Structures.

(1) Specialized architectural treatment of specific project features can frequently enhance the overall appearance of the project at minor added cost. Provisions for such treatment should be considered in the planning process.

(2) The most important broad objectives for effective landscaping and planting are (a) to break the monotonous expanses of large buildings; (b) to give the buildings and their surroundings character, and reduce the apparent scale; (c) to reduce air conditioning loads; (d) to provide shade and wind-breaks; (e) to reduce noise, dust, and erosion; and (f) to make the areas more attractive and livable. Indigenous planting should be used to reduce project maintenance costs.

c. Embankment and Dike Slopes. Erosion control is essential and screening by planting and landscaping is advocated where practical and technically sound.

d. Contractor Work Areas. These areas should be confined to the minimum necessities, planned for minimum despoilment, and restored at completion of project.

e. Quarries, Borrow Pits, and Waste Disposal Areas. Those that will be visible or may become visible from the project or from public roads or railroads should be graded and landscaped as practicable to restore a natural look to the area. If such areas will not become visible to the general public, they may receive such minimum treatment as can be provided at nominal cost. Waste disposal areas should be chosen to minimize problems of restoration and screening and should be designed to avoid air and water pollution. Seeding, sodding, and plantings should be considered where appropriate because of the location.

f. Roads and Railroads. When these are being designed in the project area, consideration should be given, where possible, to more scenic alignments that will be compatible with the natural terrain and will minimize scars on the hillsides. Landscaping of roads should be in general accordance with the American Association of State Highway Officials' publication, "Landscape Design Guide" (1965).

g. Overlooks. Particular care should be given to insuring that the best possible views are available from overlook sites. All project features visible from the overlook should be treated to present a pleasing appearance.

h. Floodways and Channels.

(1) Alignment. Where feasible, care should be exercised to preserve vegetation, scenic points or historical buildings that may be within or adjacent to channels and floodways.

(2) Slope protection. In urban areas, slopes should be turfed where feasible. When riprap is required on slopes of channels used extensively for recreational boating, consideration should be given to provision of turfed or paved areas on the inside bank of bends to provide landings for boats, particularly at areas otherwise suitable for recreational development. In urban areas, consideration should be given to providing walkways along channel berms, with access to street level at bridges. Suitable sodding, plantings and preservation of trees can be used to further enhance the appearance of urban channels.

(3) Spoil piles along channels should be shaped, landscaped, and protected from erosion as necessary to prevent unsightliness.

i. Continuing Maintenance. Serious consideration should be given to including frequent cleanup as an item of required local cooperation for channel and floodway projects. Channels should not be used as a dumping ground. Local interests should also be required to enforce regulations against spillage of pollutants in streams and harbors. Regular removal of debris will help prevent marinas and harbors from becoming unsightly from floating drift.

j. Reservoir Backwater Areas. In connection with reservoir projects, potential problem areas should be considered in backwater reaches where denudation of vegetation and deposition of sediment create unsightly conditions and possible health hazards due to poor drainage and related mosquito problems. Some of the adverse aesthetic effects of the reservoirs could be eliminated by the construction of sub-impoundment reservoirs under cooperative arrangements with local interests.

SECTION III

PLANNING POLICIES AND PROCEDURES

1. ALL VIEWPOINTS

Planning policies and procedures will consider all viewpoints - National, Regional, State and local - and how objectives of each fit into the overall study objectives. The present economy will be described and analyzed as well as the past, with consideration of present trends and future projections, along with foreseeable specific economic problems of the Basin and subbasins. For any project or all projects proposed, it will be shown how contributions will be made to economic growth and to the well-being of the people. Relationships shall be described between all facets of each proposed project and all objectives, including consideration of alternative proposals and with due consideration for environmental quality, State and local requirements, future growth, and national security.

2. MULTIPLE-PURPOSE PLANNING

In multiple-purpose planning, all uses and purposes shall be considered on a comprehensive basis. Each proposed purpose shall first be reviewed with relation to its projected needs and the impact of possible inclusion into each considered project. All means of accomplishment for each purpose shall be reviewed, to determine the desirability of meeting the various study objectives and for determination of a logical choice between development alternatives by projects singly, in combination, or by alternative non-project methods. The plan shall cover the entire Grand River basin and will fully develop the possible advantages of multiple-purpose water and related land usage, reconciling any differences arising from competitive uses. The Plan shall recognize and describe the relationships of all natural resources and explicitly take into account the interrelationships between surface and ground water.

3. INDIVIDUAL PROJECT PLANNING

Individual project planning to meet single-purpose objectives may be included, where feasible, as adjuncts to the comprehensive plan. Where single-purpose projects help meet Basin objectives and do not conflict with or preclude other measures, they should be included in the comprehensive plan. When an individual project plan does not clearly

fit into a multiple-purpose plan, but it is felt that, nonetheless, for overriding reasons, the project is required and should be proposed on an individual basis, the reasons for proposing to proceed independently shall be fully discussed in the Main Report. A full discussion will also be provided on the impacts that can be foreseen of the single-purpose project or multiple-purpose projects in the Plan, as well as existing and potential other water uses.

4. COORDINATION

Planning thru all phases, including review, shall be coordinated with all applicable Federal agencies and with all local interests. At the outset of the comprehensive study the State and its agencies will be recognized as representing local viewpoints, except in cases where another designation is made. When the final report is developed, cooperation will be requested of known local interest groups as required, in seeking local viewpoints, and full consideration will be given to their responses in preparation of the final report.

5. RELATION TO EXISTING LAWS AND EXECUTIVE ORDERS

The final document will include statements on the aspects of the Plan which are directly or indirectly brought about by conformance with or any deviation from existing general or specific requirements, laws and/or executive orders.

SECTION IV
PLANNING CRITERIA

1. GENERAL

Formulation of the comprehensive plan will reflect full consideration of all study objectives as defined by Senate Document No. 97, its Supplement No. 1, and the Interdepartmental Staff Committee of the ad hoc Water Resources Council and its successor now known as the Council of Representatives of the Water Resources Council.

a. Expectations. Formulation will be made within the context of a projected economy based upon existing knowledge and trends and the following expectations:

(1) Expanding economy. During the projection period, 1970 thru 2020, there will be an expanding national economy wherein there is a growing population and a higher standard of living, increased amounts of goods and services are required, and needs are met of all national and international commitments.

(2) Balanced supply and demand. During the projection period, an environment will exist wherein supply will balance with demand at an efficient pattern of production and level of resource employment.

b. Principle of Net Benefit Maximization. Plans will be formulated utilizing the principle wherein the most effective use of economic resources required for a project is made, if they are utilized in such a way that the amount by which benefits (tangible and intangible) exceed costs is at a maximum.

c. Permit Timely Application. Plans shall be formulated to permit timely application of flexible standards and benefits, to meet conditions of less than full employment for the Nation and in particular, in local areas where there is chronic and persistent unemployment or under-employment as determined by the Economic Development Administration.

d. Include Public Viewpoint. All project effects that encompass the public viewpoint and may be expected shall be considered. These shall include those effects that are beneficial (favorable), adverse (unfavorable), short-range, long-range, tangible and intangible. The extent to which such evaluations will be carried out will depend upon how well such effects can

be perceived, isolated, and converted into terms that permit evaluations of comparability, preferably by dollars. The entire project formulation process will be largely a matter of measuring, weighing, and comparing alternatives to determine their efficiency in accomplishing the desired objectives.

e. Recreation and Fish and Wildlife. Full consideration will be given to recreation and fish and wildlife enhancement and development among other purposes, as set forth in the Fish and Wildife Coordination Act (48 Stat. 401, as amended); Public Law 89-72, 89th Congress, S.1229, approved 9 July 1965 and cited as the "Federal Water Project Recreation Act." Plans will include, at various levels of detail, the recreation and fish and wildlife facilities required to insure full development of recreational opportunities, consistent with projected needs and subject to reasonable allocations of resources among conflicting purposes.

f. Site Preservation. Consideration will be given to any apparent urgent needs for land acquisition or other methods of site preservation in advance of project construction and such considerations will be discussed in the report.

g. Alternative Plans. All technically feasible alternative plans and solutions to meet the determined needs will be considered and reported upon in full detail.

The final report will clearly describe such alternatives, their anticipated consequences, and the adjustments made to the adopted Plan to settle minor differences which were resolved by compromise. Where major differences exist in considered plans and intangible benefits and these differences constitute the principal variance in the planned objectives, each such alternative shall be fully weighed and consensus will be attempted. The development of such alternative plans by review authorities will be resorted to only if it is clearly impossible to attain Coordinating Committee consensus on a plan. However, if significant value judgments are exercised to obtain a consensus, requiring compromises between maximizing of tangible and intangible benefits, the report will clearly state that such judgments have been used. Initial comparison of alternative plans will utilize primary benefits principally, resorting to secondary

benefit evaluations for resolving of differences. In weighing secondary benefits, the amount of such benefits attributable to the meeting of any national objectives will be explicitly identified in the benefit-cost ratio. Also, any portion of such ratios attributable to the meeting of State or local objectives will be identified and computed in a separate benefit-cost ratio.

2. DEFINITIONS

The definitions of the basic terms in project formulation are given below:

a. Project. Any separable integral physical unit or several component and closely related units or features, or system of measures, undertaken or to be undertaken within a specified area and time for the control or development of water and related land resources, which can be established and utilized independently or as an addition to any existing project, and can be considered as a separate entity for purposes of planning, evaluation, financing, construction, management, or operations.

Separable units or features will generally be considered as separate projects.

b. Benefits. Increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project, as compared with conditions without the project. Benefits include tangible and intangibles and may be classed as primary or secondary.

c. Tangible Benefits. Those that can be expressed in monetary terms based on or derived from actual or simulated market prices for the products or services, or, in the absence of such measures of benefits, the cost of the alternative means that would most likely be utilized to provide equivalent products or services. This latter standard affords a measure of the minimum value of such benefits or services to the users. When costs of alternatives are used as a measure of benefit, the costs should include the interest, taxes, insurance, and other cost elements that would actually be incurred by such alternative means rather than including only costs on a comparable basis to project costs.

d. Intangible Benefits. Those benefits which, although recognized as having value in satisfying human needs or desires, are not fully measurable in monetary terms, or are incapable of such expression in formal analysis.

Each type of benefit usually has a part which is readily measurable and may have a part which is not measurable or not readily measurable. The significance of this latter part shall be based upon informed judgment.

e. Primary Benefits. The value of goods or services directly resulting from a project, less associated costs incurred in realization of the benefits and any induced costs not included in project costs.

f. Secondary Benefits. The increase in the value of goods and services which indirectly result from the project under conditions expected with the project as compared to those without the project. Such increase shall be net of any economic non-project costs that need be incurred to realize these secondary benefits.

g. Economic Costs. The value of all goods and services (land, labor and materials) used in constructing, operating and maintaining a project or program; interest during construction and all other identifiable expenses; losses, liabilities and induced adverse effects connected therewith, whether in goods or services, whether tangible or intangible, and whether or not compensation is involved. Project enconomic costs are the sum of installation costs; operation, maintenance and replacement costs; and induced costs.

h. Installation Costs. The value of goods and services necessary for the establishment of the project, including initial project construction; land, easements, right-of-way, and water rights; capital outlays to relocate facilities or prevent damages; and all other expenditures for investigations and surveys, and designing, planning and constructing a project after its authorization.

i. Operation, Maintenance and Replacement Costs. The value of goods and services needed to operate a constructed project and make repairs and replacements necessary to maintain the project in sound operating condition during its economic life.

j. Induced Costs. All uncompensated adverse effects caused by the construction and operation of a program or project, whether tangible or intangible. These include estimated net increases if any, in the cost of Government services directly resulting from the project and net adverse effects on the economy such as increased transportation costs.

Induced costs may be accounted for either by addition to project economic costs or deduction from primary benefits.

k. Associated Costs. The value of goods and services over and above those included in project costs needed to make the immediate products or services of the project available for use or sale. Associated costs are deducted from the value of goods and services resulting from a project to obtain primary benefits.

l. Taxes. Allowances in lieu of taxes or taxes foregone will not be included in project economic costs, except as required by law.

m. Interest During Construction. This is an accrued interest that is applicable during the construction period (usually longer than a year) until the project (or an identifiable portion thereof) becomes available (in-service). The current Federal interest rate will be used unless non-Federal monies are involved and then the applicable interest rate will apply. It shall be computed as follows in preliminary studies: Current interest rate x 1/2 estimated construction period x estimated cost.

n. Supply. The quantitative measure of available (existing and immediate programmed) resources for designated water and related land uses. The unit of measure varies depending on the use of the resource.

o. Demand. The quantitative measure of the immediate and projected use, both expressed and latent desire, existing within the population. The unit of measure varies depending on the use of the resource.

p. Needs. Generally, a quantitative measure of the difference between supply and demand which can be measured in monetary units of tangible benefits. In addition, needs may also be established independent of supply and demand relationships and/or the benefits cannot readily be identified in monetary units. A comparison of needs in monetary terms relates the significance of the individual uses. However, where monetary units are not available to evaluate needs, a detailed description of the intangible benefits that can be derived in meeting the needs shall be included in order that they may be adequately evaluated with the tangible benefits.

3. SPECIFIC SETTING

Each project will consider the Grand River Basin's present and future economy as set forth in Appendix O - Economic Base Study. Project justification statements will describe precisely the manner in which the project

will meet projected needs, will help and promote growth and well-being of the people and will describe project effects with and without the project. Further, discussion will be included on the anticipated consequences to the Nation and the Basin if the needs are not met either completely or partially and will also include descriptions of any other possible resource improvements to be expected.

4. BENEFITS AND COSTS

Each alternative plan will be formulated on the same basis, with due regard to all pertinent benefits and costs, both tangible and intangible. Benefits and costs will be expressed in comparable quantitative terms (dollars when possible) to the fullest extent possible. All multiple-purpose plans considered in formulating the comprehensive plan will consider all objectives and purposes possible and will be selected based upon the following sequential criteria:

a. Tangible benefits exceed project economic costs.

b. Each separable unit or purpose provides benefits at least equal to its costs.

c. The proposed scope of development is such as to provide the maximum net benefits.

d. There is no more economical alternative means, on a comparable basis, possible to accomplish the same purpose or purposes which would be precluded from development by implementation of the Plan.

e. In sequence:

(1) Only tangible benefits and project economic costs will first be considered to establish a base for comparison.

(2) Intangible benefits will be taken into account and plans adjusted accordingly.

(3) Once the optimum-tangible-benefit plan is selected, it will be reviewed, utilizing intangible consideration, and adjusted so as to take into account these benefits.

Any resulting departures from the optimum-tangible-benefit plan, and any other special consideration shall be fully documented in the report.

5. TIME CONSIDERATIONS

a. Construction Needs of the Present and Up to the Year 1985. (Called "Immediate Needs" in Section V) - The Plan will identify each specific

structural and nonstructural project proposed for completion or accomplishment during this period, together with a time table for completing the major elements.

b. Additional Construction Needs to the Year 2020. (Called "Projected Needs" in Section V) - The Plan will identify in more general terms those measures to be carried out in two periods: 1985 to 2000 and 2000 to 2020.

6. INTEREST RATE

a. For project investment, evaluation, allocation of costs, cost sharing, and discounting of future benefits, the then current Federal interest rate as determined by the Treasury Department will be used.

b. Non-Federal interest rates, used in computing associated costs or in the alternative cost method of estimating project benefits, will conform to the standard practices of the Federal agencies involved.

7. ECONOMIC LIFE

To place lump-sum capital costs and annual costs on a comparable basis, capital costs will be converted to equivalent equal-annual-payment series using the interest rate specified above and an economic life or amortization period of 50 years. When warranted by special circumstances, the economic life used for evaluation purposes may be extended to 100 years, provided a physical life of the facility at least that long is assured. Operation, maintenance and replacement costs will be added to the amortized rates to arrive at equivalent equal annual payments.

8. PRICE LEVELS

For project screening purposes, price levels prevailing during the month of February 1960 will be used for evaluating construction costs.

a. Costs. The estimated cost will be prepared for each project reported in the study. Included in the estimate will be the project first costs for each function or objective, with appropriate contingency allowances based on the judgment of the study group, giving due consideration to accuracy of the maps, survey data and other data used in the preparation of the estimate. The estimate will include the cost of engineering and design, the cost of supervision, inspection and administration, and the cost of real estate, of acquiring the land in fee, value of improvements, minerals, water

and other rights, severance damages, resettlement and acquisition costs. Any additional factors adding to the real estate cost estimates will be identified. Relocations and improvement costs will conform to the standards of the State, County or City where the facilities are located.

b. Benefits. The estimated benefits will be prepared for each project reported in the study. These will be expressed in the physical measures summarized in Table P-2. Benefits will be evaluated using the "Interim Price Standards for Planning and Evaluating Water and Land Resources, April 1966" recommended by the Interdepartmental Staff Committee of the Water Resources Council. Where this document's recommended standards are not applicable or the price is not given, benefits will be evaluated according to the standard practices of the Federal agencies involved.

TABLE P-2

PHYSICAL MEASURES *

SUMMARY BY BENEFIT CATEGORY

BENEFIT CATEGORY	PRIMARY MEASURE	SUPPLEMENTARY
I. CONTROL OF WATER DAMAGE		
A. Flood damage reduction to existing development	10^3 acres protected	value per acre
B. Flood damage protection to future development	10^3 acres protected	10^3 acre-feet of storage number of structures
C. Drainage	10^3 acres improved usage	value per acre
D. Beach erosion control	miles of beach protected	
E. Hurricane protection	acres protected	value per acre number of structures
F. Bank and channel stabilization	miles stabilized	
II. WATER SUPPLY		
G. M&I water supply, present , future	10^3 acre-feet (af) storage 10^3 acre-feet (af) storage	10^3 acre-feet supplied annually (af/y) number of users
H. Agricultural water supply, present , future	10^3 acres serviced 10^3 acres serviced	10^3 acre-feet supplied annually (af/y) number of users 10^3 acre-feet of storage
I. Water quality control, present , future	10^3 acre-feet (af) storage 10^3 acre-feet (af) storage	10^3 acre-feet supplied annually (af/y)

* In preparing studies and listing benefits, "primary" measures should be used if possible. Supplementary measures should be used only where primary measures are not *available or as supplements* to the primary measures. It should be recognized that the supplementary measures are furnished as illustrations of additional data which may be useful. It is not intended to limit the area of description of supplementary data. Use of any supplementary physical measure which is considered appropriate is encouraged.

NOTE: 10^3 is one thousand and 10^6 is one million

TABLE P-2 Cont'd

	BENEFIT CATEGORY	PRIMARY MEASURE	SUPPLEMENTARY
III.	J. COMMERCIAL FISHERIES....................	tons of increased fish catch annually	
IV.	RECREATION		
	K. General recreation.....................	10^3 recreation days annually (rda)	type of use number and type of facilities
	L. Fish and wildlife......................	10^3 recreation days annually (rda)	
	M. Recreational boating...................	boats annually	boat days
V.	WATER NAVIGATION AND TRANSPORTATION		
	N. Harbors................................	10^3 tons of increased commerce annually	10^3 tons of commerce annually major commodities value of commerce annually
	O. Inland Waterways.......................	10^3 ton-miles of increased commerce annually	10^3 ton-miles of commerce annually major commodities value of commerce annually
VI.	P. HYDROELECTRIC POWER....................	kw (capacity)	10^6 kw-hours annually

TABLE P-2 NOTES
Benefit Category
Definitions - Physical Measures

Acres Protected - estimate of area in the flood plain within standard project flood limits. Include only the acreage within the immediate drainage area. No physical measure is required for downstream benefits accruing from reduction of mainstem flow.

Acres Improved Usage - estimate of area for which drainage will result in usage which will produce value exceeding the detrimental effect of drainage.

Miles of Beach Protected - estimate of length of shoreline to which benefits will accrue from construction of shore protection structures.

Miles Stabilized - estimate of length of bank to which benefits will accrue from construction of bank protection.

Acre-Feet Storage - estimate of storage available for allocation to the specific purpose.

Acres Serviced - estimate of acreage which will be irrigated as a result of construction of the project.

Annual User Days - self explanatory.

Number of Boats Each Year - number of boats berthed at the harbor or mooring facility for the recreation season. Day use from launching ramps will be counted as general recreation.

Increased Fish Catch Annually - estimate of increase in commercial fish harvest expected to result from project construction

Tons of Commerce Annually - estimate of increased tonnage of commodities expected to move into or out of the improved facility (tonnage which would not move into or out of the existing facility without improvement).

Ton-Miles of Commerce Annually - estimate of increased tonnage of commodities expected to move on the improved waterway times the length of the improved waterway.

Kilowatts-Capacity - name plate capacity of installation which corresponds to the estimated cost shown.

Note: On those projects for which the physical measures defined above are inadequate, the information furnished should be supplemented by footnote. The footnotes should present alternate physical measures where possible.

SECTION V

CRITERIA FOR DETERMINING WATER AND LAND RESOURCE NEEDS, BY PLANNING SUBAREAS

1. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

a. Method of Determination. Data on municipal water use will be obtained from "Municipal Water Facilities, 1963 Inventory," published by the Department of Health, Education, and Welfare, supplemented from State records and inventories compiled for the Great Lakes-Illinois River Basin (GLIRB) project. Total and per capita usage will be obtained for each community and summarized by planning subareas. A breakdown of industrial water use, by Standard Industrial Classification (SIC) and by counties, has been obtained from the Bureau of the Census in the GLIRB project. These data are for the year 1959; similar data for 1963 will be obtained from the Census Bureau, if possible.

b. Immediate Needs (to 1985). Investigation will be made as to any curtailment of present use due to inadequate supply. Adequacy of present sources will also be appraised with regard to drought flows of surface stream supplies, available storage capacity, and dependable yield of ground water aquifers. The extent of imbalance, if any, of present supply to meet demands will be estimated.

c. Projected Needs (1985 to 2020). Municipal water demand is affected by the following independent variables:

(1) Population served.

(2) General state of the economy.

(3) Standard of living of the population served.

(4) Rank (with respect to size) of population served.

(5) Climate.

(6) Price of water.

(7) Extent of metering.

Because general municipal water demand is affected most by the population served, daily water use per capita, and past trends in per capita use, it will be determined from the records. Past records will also be studied to identify the influence, on per capita factors, of the remaining variables in the above list.

Future populations to be served from municipal water systems, in each subarea, will be obtained from the economic base study which will also provide an outlook for the future regarding such factors as general state of area economy and standard of living. Per capita factors will be selected and multiplied by the projected populations, for each subarea, and each major metropolitan area (demand center), at time intervals sufficient to define the shape of a future demand curve to the year 2020.

Future municipal water needs as determined by the foregoing procedure will include that portion of industrial water which may be considered as principally population-influenced, and thus a part of the per capita use of typical communities. Separate studies will be made for the major water-using industries of each subarea; those industries for which the water demand is related only indirectly, if at all, to the population of the area in which the industry is located.

Industrial water demand is affected by the following independent variables:

(1) Product manufactured.

(2) Manufacturing process.

(3) Amount of production.

(4) Rate of production.

(5) Cost of water supply.

(6) Cost of waste water disposal.

Each of the above factors will be examined to determine its effect on the basic uses of industrial water supply, cooling, and processing. Projected growth in industrial activity, obtained from the economic base study, will be translated into estimates of accompanying water demands. Account will be taken of expected improvement in the efficiency of water use by large industrial users, i.e,. increase in recirculation and other water-conserving practices.

2. FARM WATER SUPPLY

a. Method of Determination. Basin farm water supply needs are determined by applying realistic use rates to projected unumbers of livestock, farm population and labor force, and expected new water-using technology. All assumed uses and use rates are adapted from Water Systems

Analysis to Meet Changing Conditions, Agricultural Engineering Department, Michigan State University, Information Series 152, File No. 18.35, using judgment as to how rapidly various water-using technologies will be adopted by farm operators.

b. Immediate Needs. Immediate needs reflect estimated current use by livestock, population and labor force in producing known quantities of agricultural products. Account is made of livestock loss to mortality, pesticide spray-water needs, and such incidental farm family use as lawn and garden watering.

c. Projected Needs. Projected livestock and livestock product output is converted into animal numbers by class of livestock, including all necessary young and non-producing members, and expected water-use rates applied. Differential use rates are assumed between rural farm families and the families of hired farm workers and applied to projected numbers.

3. IRRIGATION WATER

a. Method of Determination. Basis of determining gross demand.

(1) Determine moisture deficiency and physical yield loss relationships.

(a) Correlate U. S. Commerce Department, Weather Bureau (Palmer area weather variables) with Statistical Reporting Service historical yields. This will be on an area basis.

(b) General estimates for differences in soil moisture holding capacities, soil texture and levels of production.

(2) Refine and classify existing soil management groups according to moisture-holding capacity, texture and productivity level.

(3) Develop irrigation costs on an "on farm" basis which would include only the distribution system and not a water source cost.

Base water use on application efficiency and average historical moisture deficiency.

(4) Budget yield increase and associated water distribution costs.

(a) Determine cropping patterns and maximum acreages of soils economically feasible to irrigation for general field crops (which includes potatoes) through linear program.

(b) Determine likely irrigation of specialty crops.

Specialty crops include fruit, small fruit and vegetable crops.

b. Immediate Needs.

(1) Feasibility of irrigable areas will be mapped under present economic conditions.

(a) Irrigable soil management groups will be identified and located from county soil maps and placed on overlays. A minimum size of 320 acres would be delineated. An estimated percentage would be used as the basis for determination of each major management group. Land use will be obtained from review of aerial photographs.

(b) Acreages of each potential irrigable group by land use will be determined and identified. These will be measured and catalogued in each evaluation unit and for each subbasin.

(2) Source and cost of water supply will be determined.

(a) Storage reservoir sites will be identified:

1. Using present Agriculture and Corps of Engineers inventory data.

2. Considering water yields, evaporation, transpiration, permeability, seepage losses, etc.

3. Determining maximum water storage volume.

(b) Location of ground water and effective well yield determination for irrigation purposes will be identified. Information and data will be obtained from U.S.G.S. for this relationship.

(c) Effective volumes from streamflow and inland lakes will be determined.

(3) Costs and benefits will be compared. Impoundment storages and streamflow reaches will be determined on basis of zones established on maps. Ground water will be determined on basis of g.p.m. dependent on depth of aquifers. Pumps, pumping costs and transmissions will be included.

c. Projected Needs.

(1) Feasibility of irrigable areas will be mapped under projected economic conditions.

(2) Source and cost of water supply are determined.

(3) Costs and benefits are compared.

4. NAVIGATION WATER

a. Method of Determination.

(1) Establish the general description of the waterway and harbor including stages, conditions, controlling depths, history of existing projects and improvements, planned construction, present use and type of vessels using the facilities.

(2) Analyze navigation needs determing extent, character, and data affecting all modes of transporation for the area including compiling data on commodities produced or imported and how they are transported. Compile waterborne commerce in short tons both for existing and prospective traffic.

(3) List improvements desired by local interests, source and reasons for their requests.

(4) Summarize present and projected use of the waterway by number and type of watercraft, both commercial and recreational.

(5) Prepare a plan of improvement to meet the needs.

b. Immediate Needs. Immediate needs for commercial shipping will be based on desires of local interests and on a study of requirements and anticipated waterborne commerce for the harbor and the waterways as determined by economic projections of population, industry and commerce.

Recreational boating needs will be based on desires of local interest and anticipated use as determined by applicable projections of the economic base study.

c. Projected Needs. Long-range goals will be based on projected waterborne commerce. Size, capacity and number of vessels will be analyzed along with other factors that affect water and river transportation facilities.

5. HYDROELECTRIC AND THERMAL POWER

a. Method of Determination.

(1) Hydroelectric Power Plants. Hydroelectric power plants have several important advantages over thermal plants. They neither consume water, nor do they heat the waters of rivers and streams with the possibility of causing thermal pollution as thermal plants do; and they do not contribute to air pollution.

The maintenance costs of hydroelectric plants are relatively low and in many cases plants can be designated for automatic or remote control operation. The ability to start quickly and change power output rapidly make hydroelectric plants particularly suitable for carrying peak loads.

(a) Criteria for Initial Screening of Hydraulic Feasibility of Hydroelectric Power Development.

1. Conventional Hydroelectric Projects.

a. General Criteria. All potential hydroelectric power sites should be investigated to determine their physical and economic feasibility. The economic feasibility of including hydroelectric power as an added purpose of multiple-purpose reservoir development should also be investigated. A hydroelectric project screening form has been developed for use in determining economic feasibility of a project under consideration.

b. Specific Criteria.

1. Prime Power. The most critical streamflow period of record should be used to determine the prime power available. Prime power will be that amount available over the critical period, from that portion of the yield allocated to power generation, with proper adjustment for reduced head due to peaking operation.

2. Average Annual Energy. The streamflow period of record, adjusted to at-site conditions and for upstream development as necessary, should be used in the determination of average annual hydroelectric energy potentially available.

3. Storage for Power. The power drawdown of storage in multiple-purpose reservoirs is based on the conservation storage provided for municipal, industrial and irrigation purposes, except where economic considerations indicate that power drawdown storage should be based on an amount greater or less than the conservation storage. In projects without power, a varying amount of inactive storage capacity generally is provided as sediment reserve and for recreation and fish and wildlife development. This inactive storage might need to be increased in order to assure a minimum operating head for economic power production. In general, and when

possible, the maximum economic ratio for power is produced where the minimum head (during the peak load season) is at or near critical head, i.e., where the capability at minimum head is equal to installed capacity. In any event, for those cases where the minimum head is dictated by purposes other than power, in order to avoid excessive cavitation of the turbines, the minimum head should not be less than 65 percent of the rated head for Francis-type turbines and not less than 50 percent of the rated head for Kaplan-type turbines.

4. Rated Head for Hydraulic Turbines. For design of hydraulic turbines, the rated head should be based upon the average head during the critical hydro period; modified where required by economic considerations and where reservoir operations for other water uses would establish a minimum pool level much below critical head, with correspondingly reduced minimum peaking capability. The rated head is considered to be the head at which the turbine output at point of best efficiency equals the rated generator capacity in kilowatts.

5. Plant Factor. For screening type studies, the plant factor during a critical year for a power plant at a reservoir will be assumed to be ten percent based upon the assumed dependable capacity. This will determine the installed capacity to be considered and this will later be confirmed or revised as a result of more detailed studies. The plant factor for an individual plant may also be increased when required as an economical alternative to providing a regulating reservoir to iron out daily peak power releases.

6. Installed and Dependable Capacity. The minimum peaking capability, based on the minimum head available during December of the critical period, is to be considered as dependable capacity, based on the firm energy available for the specified monthly plant factors.

On the basis that the hydroelectric power plants would operate in a large, interconnected system, unit size is not restricted by marketing conditions or replacement requirements. The size is based on economics, design, and operating criteria. When the installed capacity of a power plant is to be divided into an initial and ultimate number of generating units, the initial installation should be economically justified, the

power therefrom being considered to be marketable shortly after the project is put into operation.

c. Power Values. At-market values for capacity and energy are shown in paragraph (b) below. These values are only for use in screening. If more detailed power studies of a potential power installation are justified, more precise values will be furnished taking into account the location and size of the plant with respect to existing transmission in the area, and by reducing the at-market values to an at-site basis.

d. Load Studies. For purposes of screeening studies, detailed investigations as to the earliest year of usability for the hydro in question are not warranted. The rapidly growing loads and increase in interconnected operations make it possible to immediately utilize all of the economical conventional hydro potentially available provided that its installation is made known sufficiently in advance to allow postponement of other scheduled capacity.

e. Economic Studies. Investment costs and annual charges should be computed according to usual criteria based on current price levels.

f. Selection for Further Study. Power facilities which reveal a benefit-cost ratio of 0.8 or more as a result of screening studies should be analyzed on a more detailed basis.

2. Pumped Storage Hydroelectric Projects.

a. General Criteria. Pumped hydro storage is unique among methods of electric generation in being dependent upon other power sources for energy supply. It functions as an energy accumulator which stores low-cost off-peak energy by using such energy to pump water from a lower to a higher reservoir from which the water can be returned through the turbines to generate power during peak periods when it has capacity as well as energy value. Thus, a prerequisite for such development is the availability of low incremental cost off-peak energy for the pumping or charging cycle. The source of such energy will almost always be from thermal plants, rarely from hydroelectric installations.

Reduced equipment cost brought about by the development in recent years of the reversible pump-turbine unit, permitting the pumping and

generating operations to be combined in a single machine, has contributed significantly to the economics of pumped storage installations.

b. Specific Criteria. The following generalizations should be used in reconnaissance or preliminary evaluations of possibilities for pumped-storage installations:

1. A head of at least 150 feet should be available between the upper and lower reservoirs.

2. Generation of about 1,000 kwh per kw per year may be assumed as typical for peak load operations, unless other use factors have been indicated by appropriate entities.

3. For each 2 kwh of generation, assume 3 kwh of pumping energy required.

4. Assume pump discharge capacity equal to 0.8 of the turbine discharge capacity.

5. Sufficient usable storage in the upper reservoir should be available to allow at least a daily cycle of generating and pumping.

6. In estimating the cost of a reversible unit, the cost of a pump-turbine and generator-motor may be assumed to be about 150 percent of the cost of a conventional turbine generator for the head involved.

(b) Criteria for Initial Screening of Economic Feasibility of Hydroelectric Power Developments.

At-Market Cost of Alternative

Steam-Electric Power

Area	Private Steam-Electric System (Nuclear) Capacity Cost	Energy Cost
	($/kw)	(mills/kwh)
Grand River Basin Study Area	28.50	1.30

Note: Costs do not reflect hydroelectric advantage or energy penalty factors.

When utilizing the at-market costs of alternative steam-electric plants, they should be associated with the following data:

(1500 kw plant) Alternative steam-electric unit size: 750,000 kw
Capital costs of steam-electric plants: $150/k/w
Alternative steam-electric transmission: Sufficient 345 kv circuits to transmit the plant's output a distance of 20 miles.

(2) Water Requirements for Steam-Electric Generation.

(a) General Criteria. Under average conditions about 4900 Btu of heat is transferred to the cooling water for each kilowatt-hour generated. Experience has demonstrated that the most economical plant designs provide for cooling water temperature rises of 15 to 20 degrees Fahrenheit. Based on an average temperature rise of 18 degrees about 100.2 acre-feet of cooling water is required per million kilowatt-hours generated.

(b) Cooling Pond. If the cooling water is taken from, and discharged back into, a pond, lake, or reservoir, the heat in the circulated water is dissipated to the atmosphere, through convection or induced evaporation. The water that is evaporated is lost to the air, and so becomes a consumptive use attributable to the power operation. This amounts to about 1.10 acre-feet per million kilowatt-hours generated. The cooling pond should be about one acre in size per thousand kilowatts.

(c) Flowing Stream. If the cooling water is released to a flowing stream, the evaporation loss is probably somewhat less than for ponds, but little statistical information is available to support this supposition, and losses are conservatively estimated to be about the same as for ponds. As a rule of thumb, the minimum flow in a receiving stream should be at least twice the maximum discharge from the plant's cooling system.

(d) Cooling-tower. In cooling-tower systems, evaporation accounts for about 85 percent of the cooling, and there are some water losses because of spray drift as a result of wind. The consumptive uses at towers average about 1.47 acre-feet per million kilowatt-hours.

(e) Nuclear. Nuclear plants have a slightly higher heat load to dissipate through the condenser (using current design standards) and thus require about 119.6 acre-feet per million kilowatt-hours generated as compared with 100.2 for fossil-fueled plants. Consumptive uses are correspondingly higher.

(f) Summary. All of the figures shown above represent hypothetical conditions, believed to be about average for the circumstances that would be encountered in the United States. Obviously there are many

variables of plant design, location, meteorological conditions, etc., that might cause the figures for a specific plant to vary drastically from those suggested here.

b. Immediate Needs. Immediate needs will be based on electric power requirements and necessary capacity additions, taking into account retirements, reserves, interchange of electrical energy, and utilizing the criteria covered under paragraph "Method of Determination" above.

c. Projected Needs. Projected needs will be based on forecasts of electric power requirements, including reserves, less existing capacity taking into accout retirements.

6. WATER QUALITY CONTROL

a. Method of Determination. As used here, the term, "Water Quality Control Needs", refers to needs from streamflows and regulation of such flows, to assimilate wastes remaining after accomplishment of adequate treatment and other methods of controlling wastes at the source. A necessary background to the subject is the consideration of other quality control measures, which include exclusion of waste material at the source, and collection, transport, and treatment of waste-bearing waters. This background will be provided by the comprehensive water pollution control study which is being made by the GLIRB Project and its cooperating agencies.

The locations of critical points for quality control will be identified, along the main stem from Jackson, Michigan to the mouth. Consideration will be given to other critical points on tributaries, if the study discloses such points.

Streamflow requirements will be determined for each critical reach of the stream. It is expected that maintenance of adequate dissolved oxygen to support the desired water use will be the primary quality characteristic that governs flow requirements.

The demand hydrograph, at a critical point, will be defined by stating mean monthly flows required in each calendar month.

Ability of existing flows to meet this demand will be assessed on a yes-no basis by comparing maximum required flows with the seven-day minimum flows of specific drought conditions, as further defined. These flows are determined by arraying, in order of magnitude, the lowest average flows for seven consecutive days in each year of record, plotting this flow vs percent

probability, and drawing a smooth curve. Plotting positions will be calculated by the formula, R/N+1, in which R is rank and N is the number of years of record. Where a gaging station streamflow record is not available for the critical point on the stream, interpolation from the nearest record stations will be used.

If the maximum required streamflow is less than the 7-day flow at 90 percent probability (once-in-10-year recurrence), it will be concluded that further regulation of streamflows for quality control will not be required at that point - unless, of course, the streamflow regimen is altered by other demands on the resource such as withdrawals for irrigation.

Where flow regulation for quality control is required, the 3 principal variables in the problem of estimating the amount of regulation are:

(1) Degree-of-treatment of wastes.

(2) Protection level (Minimum DO).

(3) Assurance level (Percent probability or recurrence interval).

In compliance with the law (Federal Water Pollution Control Act, as amended) degree-of-treatment will not be treated as an independent variable below the level of "adequate" treatment.

For purposes of this study, adequate treatment is defined as the best treatment which has been demonstrated to be attainable in full-scale experience with conventional technology. Degree of treatment may, in appropriate cases, be varied in the range of advanced techniques which have been demonstrated on a laboratory or pilot scale.

Protection level will be varied, in analysis of alternatives, within the range 2 to 6 parts per million minimum DO. For a final answer and proposed plan, a minimim DO will be adopted after completion of studies and consultations aimed at defining specific goals to be met.

A 6-step procedure for defining quality goals is being followed by the GLIRB Project, in cooperation with the Michigan Water Resources Commission and by participation of various other groups. Procedure is as follows:

(1) Formulation of a general statement of water quality policy.

(2) Selection of general water use categories.

(a) Municipal water source.

(b) Industrial process water.

(c) Recreation.

1. Whole body contact.

2. Partial body contact.

(d) Irrigation water.

(e) Fish and aquatic life.

1. Tolerant

2. Facultative

3. Intolerant

(f) Wildlife and livestock watering.

(g) Hydroelectric power.

(h) Commercial shipping.

(i) Cooling water.

(j) Wastewater assimilation.

(k) Aesthetics.

(3) Selection of significant water quality parameters for each use category.

(4) Setting numerical values on water quality parameters for each water use to be used as guides in establishing the goals.

(5) Delineation of stream sectors and listing of present and future water uses to be accommodated in each sector.

(6) Establishment of water quality goals by pairing water uses with the water quality required for such uses. In this process, the aims will be: widest possible accommodation of multiple uses of a stream for which a need is identified; and maintenance of cleanest water attainable at reasonable cost. The procedure outlined above will require definition of drought flows in an annual "supply" hydrograph for each assurance level to be considered.

b. Immediate Needs. Immediate needs will be met by adequate treatment as defined by paragraph "Methods of Determination." Degree of treatment may be varied where necessary in the range of advanced techniques which have been demonstrated on a laboratory or pilot scale.

c. Projected Needs. The determination of future needs relies in part on the translation of economic and population projections into probable waste discharge which can be expected to occur as a result of such growth. Water quality monitoring will of course augment this information as to the actual situation as growth occurs. The water quality needs thus determined will be met primarily by expanded waste treatment facilities, but also by additional advanced waste treatment techniques as the latter become more technologically and economically feasible. Storage for water quality control will be considered only where adequate treatment alone cannot provide the desired water quality level.

7. FLOOD CONTROL AND PREVENTION

a. Method of Determination.

(1) Define flood damage reaches and flood plain areas along the river.

(a) Determine land use in the flood plain.

(b) Relate land use to value and to a base year.

(2) Relate damages within each reach to a control (index) point for the reach and establish reaches so that they can be readily grouped for use in determining benefits for a project or projects.

(3) Make a flood damage survey, utilizing and updating existing data, if available.

(a) Establish the stage-damage relationship curve (Curve No. 1 - using the flood of record and higher hypothetical flood).

1. Determine maximum stage permissible.

(b) Establish the stage-discharge curve (Curve No. 2, using river gages as index points).

(c) Establish the discharge-frequency curve (Curve No. 3, using the Basin regional flood frequency study).

(4) Determine average annual damages.

(a) Establish the damage-frequency curve (Curve No. 4 - construct this curve using Curves Nos. 1, 2 and 3 and compute damages by measuring the area under the resulting curve and converting the area to dollars).

(b) Include agricultural flood damages which occur in each reach between the urban areas.

(5) Project average annual damages through the year 2020.

(a) Utilize methodology for estimating future flood plain growth.

(b) Account for revised runoff conditions.

(6) Develop methods of achieving flood damage reduction.

(a) Through control - channel improvement, levees and floodwalls, reservoirs, and diversions.

(b) Through restriction (local government) - flood plain zoning, regulation, relocation, land treatment, and flood warning system.

(7) Flood control for upstream watershed areas. Flood plain areas will be delineated. Frequency of flooding will be determined where reconnaissance indicates the economic justification of control measures. Alternative methods of control will be investigated for physical and economic feasibility.

b. Immediate Needs. Immediate needs will be determined by the following steps:

(1) Study the type of improvement to be considered for flood control and prevention such as channel improvement, floodwalls, reservoirs or a combination thereof and provide reasons for each type selected with an appropriate decision on economic justification.

(2) Provide supplemental data on projects that were studied and found to be technically and economically desirable.

(3) Determine the proper scale and scope of development, the degree of economic justification and the equitable sharing of costs and responsibilities of Federal and non-Federal interests.

Flood control for upstream watershed areas will be based on application of present U.S.D.A. policy and procedures under existing legislation and regulations.

c. Projected Needs. Future flood control or flood prevention needs will be based on estimated development and degree of protection that is existing or will occur by the year 1985. The remaining damage areas in the flood plain will be re-analyzed following the steps covered under sub-paragraph "Immediate Needs" above.

Flood control for upstream watershed areas projected needs, will be based on projected farm production requirements which would necessitate revision of present U.S.D.A. policy and procedures.

8. LAND TREATMENT

a. Method of Determination. Field reconnaissances, general knowledge, and inspection of aerial photographs will determine land treatment problems.

b. Immediate and Projected Needs. Evaluations will be made to determine the immediate and projected needs. Studies will determine the relationship of benefits to costs.

9. LAND DRAINAGE

a. Method of Determination. Areas needing drainage by virtue of soil type or position will be identified through use of aerial photographs, existing soil surveys, and other data.

b. Immediate Needs. In those areas where present drainage facilities are inadequate, evaluations to determine immediate needs will be made under existing policy and procedure to compare costs and benefits.

c. Projected Needs. Areas with inadequate drainage facilities requiring the installation of project type measures for outlets, but which cannot be installed under present policy and procedure will be evaluated under projected production requirements to determine future needs.

10. RECREATION

a. Method of Determination. The needs of the people in the Basin and the State which can be satisfied by the development of land and water resources provide both the reasons for planning and the scale of immediate and utimate development. Formulation of the plan is concerned with providing facilities, first, to meet the overall Basin needs generating from large population centers and, second, to meet the individual subarea needs. Requirements will be formulated on the following assumptions:

(1) Base year for the study is established as 1960 and the cut-off date for related statistical material to the study is established as of 1 January 1966.

(2) Plan formulation will be based on the best data and information available during the study period. 1960 will be used as the base year and the years 1980, 2000, and 2020 as key dates for projections and planning.

(3) Subarea determinations will be related to agreed boundaries for evaluation units to facilitate gathering of statistical data and determining needs.

(4) Gross recreation needs will be determined by deducting the total existing supply from total estimated demand. Total demand will consider the contributed effective populations originating from the subarea, the recreation market service area, and the Standard Metropolitan Statistical Areas (SMSA) within a zone of influence. Primary development plans will consider the above needs based on a regional viewpoint for day-use requirements.

(5) Bureau of Outdoor Recreation standards and criteria for recreation employed in developing the Nationwide Plan will be used unless there are compelling reasons to do otherwise.

b. Immediate Needs. The immediate goals of the study plan will be to identify if an imbalance exists between the recreation demand and supply for swimming, boating, water skiing, picnicking, camping, sightseeing, nature walks, and hiking activities for each subarea within the Basin. Demand will be based on existing and projected adjusted per capita participation rates, determined from ORRRC study data, applied to the present and projected effective population attributed to each subarea. Such recreation demands will be determined for the planning period and will be defined in terms of recreation day needs per activity. The supply resources at existing and identified potential outdoor recreation facilities and associated program for units located outside incorporated urban places of 2,500 inhabitants or more will be analyzed to determine the number of developed acres and the degree of facility development that exists or will occur by the year 1980. The imbalance between demand and supply will determine the extent and degree of the total unmet needs for each subarea and the Basin.

NEED METHODOLOGY

Formulation of recreation acre needs by subareas for selected summer activity.

Immediate Needs - 1960

Steps:

1.	Total effective population (1960)	×	Per capita activity	=	Estimated activity occasion by activity (1960)
2.	Estimated activity occasion by activity (1960)	×	Design load factor	=	Design load visits for activity (1960)
3.	Design load visits for activity (1960)	÷	Standard number of visits per acre for activity (1960)	=	Estimate of acres required for activity (1960)
4.	Estimate of acres required for activity (1960)	-	Existing acres for activity (1960)	=	Acres deficit for activity (1960)

To Estimate: Needs for year 1980 or selected planning year

5.	Estimated total of effective population (1980)	×	Per capita participation rate (1980)	=	Estimated activity occasion (1980)
6.	Activity occasion (1980)	×	Design load factor	=	Design load visits for activity (1980)
7.	Design load visits by activity (1980)	÷	Standard number of visits per acre for activity (1980)	=	Estimate of acres required for activity (1980)
8.	Estimate of acres required for activity (1980)	-	Existing acres plus acres of programmed construction for activity (1980)	=	Acres deficit for activity (1980)

Total effective population (TEP) is a composite of Standard Metropolitan Statistical Area (SMSA), non-SMSA, and recreation service area populations that will utilize the recreation resources of the study area.

Design load factor (DLF) is a factor used to convert the total annual visitation to design load visitation (DLV) which is the maximum number of people expected to use an area at any one time on a normal summer Sunday for which facilities would have to be provided.

Participation rate per capita (PR/C) is the number of occasions that one person will engage in a given activity during the summer recreation season.

c. Projected Needs. The long term goals will provide projection of potential demand and supply as parameters to identify the unsatisfied needs of the Basin. The timing schedule for these needs as well as a program which determines the most feasible means of meeting the recreation needs, will be made.

II. FISH AND WILDLIFE

a. Method of Determination.

(1) Criteria.

(a) Base year for the study is established as 1960 and the cutoff date for related statistical material pertinent to the study will be established as of 1 January 1966.

(b) Establishment of needs will be based on the most reliable data and information available during the study period. The target years for projections and planning will be 1980, 2000 and 2020.

(c) Subareas will follow those established by the Economic Base Study.

(d) Needs will be expressed in terms of hunter-days and angler-days. This is the accepted means of equating the difference between supply and demand. It also provides the planner with a common denominator for predicting the various types and amounts of habitat to be acquired and intensity of management required to satisfy future needs.

(2) Assumptions.

(a) The relationships between hunting and fishing license sales, and human population and hunting and fishing opportunity present in 1960 will continue to exist through the target years.

(b) Latent demand, as a factor, will remain constant in future projections. Satisfaction of existing latent demand will be offset by latent desires generated by a new section of the expanding population.

(3) Demand. Determination of fishing and hunting demand is basically a people-oriented procedure. License sales are the most tangible index of hunting and fishing demand. License sales are closely correlated to, and dependent upon, population and opportunity. Projected populations are available from the Economic Base Study. Opportunity to hunt or fish will be determined by a detailed inventory of fishing and hunting habitat available in the Basin for the base year 1960. Utilizing data from projected populations and projected opportunity, multiple regressions will be developed, which determine hunting and fishing demand in man-days, for each subarea, for the target years 1980, 2000 and 2020. Estimation of Hunting and Fishing Demand:

(a) The percentage of total subarea population having a fishing license (or hunting license) is dependent upon projected population per square mile and projected fishing or hunting opportunity per capita for that subarea.

(b) Percentage of total population having a fishing or hunting license multiplied by the projected population for the target year will yield resident licensed participants.

(c) Resident licensed participants, plus unlicensed participants, adjusted by ingress-egress travel patterns, will determine total participants.

(d) An expression of latent demand (increased leisure time, increased hunting and fishing facilities, and other pertinent factors influencing the hunter or angler by the target year) will be added to total potential participants.

(e) The number of total potential participants times annual participation rates per participant will yield gross hunting or fishing demand for the target years, expressed in man-days.

(4) Supply. Determination of hunting or fishing supply, unlike demand, is basically a resource-oriented procedure. However, to compare demand and supply data using a common denominator, supply data will be converted to average man-days use per acre for a particular type of hunting or fishing habitat. To determine near-future supply, it will be necessary to learn what fish and wildlife programs are proposed for completion prior to 1980. After this date, it is exceedingly precarious to predict what the going programs will be.

Estimation of Near Future Supply:

(a) The projected changes in fishing and hunting habitat will be obtained for the period 1960-1980.

(b) Average use per acre of habitat times acres of habitat created or destroyed will yield increased or decreased man-days of opportunity available to the hunter or angler in 1980.

(c) The opportunity gained or lost by 1980 will be added to or subtracted from the opportunity present in 1960 to determine 1980 projected opportunity or supply.

(5) Needs. By comparing projected supply and demand, an expression of future needs will be obtained. The relationship in each subarea will represent either an improved hunting or fishing climate when compared to the 1960 situation, or a need for additional opportunity to fulfill unsatisfied demand. The relative amount of need, when comparing one subarea to another, will furnish comparative priorities for planning consideration.

Need will also be expressed in man-days use. The planning administrator may then match projected needs with the various options open to him to satisfy these needs in a manner which is both practical and economical.

b. Immediate Needs.

(1) The result of gross projected demand plus or minus projected supply, will determine subarea needs, in user days for 1980.

(2) The planner may find that additional programs, other than those presently proposed, will be necessary to meet 1980 needs.

c. Projected Needs.

(1) Since most agencies will be unable to furnish development programs for the years 2000 and 2020, it will be necessary to determine needs by a different method than used in determining near-future (1980) needs.

(2) To maintain future hunting and fishing opportunity or supply at comparable 1980 amounts, available opportunity per capita will be projected at rates comparable to 1980, for 2000 and 2020.

(3) The increment of increased demand from 1980 to 2000 and 2020 will then be added to any needs which exist in 1980, to predict the needs for 2000 and 2020.

(4) The planner may then use projected needs for 2000 and 2020, to develop long range habitat acquisition, lease, or management programs.

SECTION VI

STRUCTURAL AND NONSTRUCTURAL METHODS OF

PROVIDING NEEDED WATER AND LAND DEVELOPMENTS

1. GENERAL

Problems associated with water and related land can be solved by application of either structural or nonstructural methods. A combination of these methods can be employed in many instances to solve a water and related land problem. A structural solution to a problem exists where a physical structure is employed to alter the resource for a beneficial purpose. A nonstructural solution to a problem exists where a program is implemented in which the natural occurrence or condition of the resource is utilized for various beneficial purposes. Although many solutions are designed to resolve single problems, their implementation normally offers more benefits than those associated with the solution of a single problem. Although considerable data and information are available on individual solutions to problems, it is considered appropriate to include a summary which briefly describes the more familiar types of solutions to these problems.

2. STRUCTURAL METHODS

a. General. Structures used in solving problems associated with water and related land resources can be classified into two categories. One category consists of those structures which have a controlling effect on these resources. The other category is comprised of those structures that change the natural state of these resources or the conditions to which the resources have deteriorated. The more familiar structural solutions to water and related land resources problems are described in the following paragraphs.

b. Water Control Structures.

(1) Reservoirs. Reservoirs of various sizes can be constructed to control and impound water to serve many water resource needs. Small headwater reservoirs, in conjunction with other engineering measures, are effective in reducing flood damages in local areas and river reaches

immediately below the reservoirs. However, these reservoirs have little effect in reducing flood damage from medium or high flows in the lower reaches of the Basin. Reservoirs located further downstream do not reduce flood damages in the headwater areas. All sizes of reservoirs may be used in the development of a plan for flood damage reduction in the Basin. Reservoirs are also an important method of satisfying recreation needs. However, certain characteristics of reservoirs have an important bearing on their recreational value. The accessibility of the reservoir in terms of distance in miles from the demand area and the degree of difficulty in obtaining access to the different parts of the reservoir are important. The shape and stability of the water surface affects the types of recreational activities. The broad, open type lake is preferred by sailboaters and water skiers because of the maneuvering room afforded them. The narrower, more winding type of lake may be preferred by users who are most interested in the scenic quality of the lake. Reservoir fluctuation affects shoreline activities such as swimming and the maintenance of boat launching facilities. Characteristics such as the shoreline features, water quality, depth of water and seriousness of obstruction hazards, climate, and quality of fishing affect reservoir use. Reservoirs may furnish water supply for the purpose of municipal, industrial, domestic, low flow augmentation, and irrigation use. Water quality in the reservoir is pertinent for each of the above uses.

(2) Local Streamflow Control Structures. The purpose of channel improvement is to improve its efficiency to carry more water than formerly, thus reducing bank overflows and resulting flood damages. The improvement in carrying capacity of the stream can be accomplished by widening, deepening, realigning, or paving the channel. Benefits can also be obtained by cleaning the existing channel of obstructions, debris, or snags. In any channel improvement scheme, maintenance work will be required in future years to continue the full effectiveness of the improved waterway. Channel improvements are often used in conjunction with levees and reservoirs. Levees or floodwalls are a means of controlling floodwaters within the channel. The confinement of the flow usually raises the height of floods by the elimination of the overflow area; therefore, care

must be taken to allow for this increased water height in the construction of the levee or floodwall. Storm and sanitary sewers can be affected by levees or floodwalls, necessitating an interior drainage review. Bridges may also have to be raised above the levee or the design water surface profile. Roadways, drains, and railroads passing through the levees must be provided with closure structures. Greater development usually occurs behind a levee or floodwall because of the implied security and a structural failue or overtopping of the system may result in greater damage than if there had been no levee.

c. Ground Water Facilities. Ground water comprises a major source of water, but has limited uses in its natural state. The most common structural facilities necessary to extract and utilize ground water supplies are pumps, pipe lines, and water storage tanks. Ground water supplies are used extensively to meet irrigation, municipal, and industrial water supply needs. A problem that may arise from utilizing extensive amounts of ground water supplies is depletion of the supplies. Plans may be necessary to recharge ground water supplies to prevent depletion. Planning for increasing the rate of ground water replenishment would focus on shallow aquifers. Replenishment of water in areas of concentrated pumpage, if feasible, would reduce the rate of water level decline and improve the water yielding capacity of existing wells. In the future, the rate of recharge of these shallow aquifers may determine the quantities of water which can be withdrawn on a continuing basis. Measures used to replenish these aquifers can be divided into either natural or artificial recharge. In both types of recharge, it is important to know the location of prime natural recharge areas. Natural recharge rates can be increased through the use of soil conservation techniques. Mulches and grass that protect the soil against the impact of rain and retard overland flow also can increase the infiltration of water. Ground water can be replensihed artificially as well as naturally. The three principal methods of artificial recharge are water spreading, seepage pits, and injection wells. Induced infiltration from streams by pumping from nearby wells and by increasing the water contact area of the stream are other methods of artificial recharge. The physical development

of the area could determine which method would be used. High land costs in the urbanized parts of a metropolitan area would promote the use of pit and injection well methods which require little land. Spreading methods which require more land would more likely be used in rural areas. Whatever the method, artificial recharge usually requires facilities to (a) obtain, treat, and transport the water to the recharge area; (b) inject the water; and (c) provide disposal of any excess water.

d. Improved Treatment Facilities. The greater portion of the water used is returned to the various sources for reuse. Thus, along the river, each successive downstream community reuses a portion of the flowing water time and again. Each use of the water may add pollutants to the water. The pollutants are added in varying amounts depending on the treatment, or lack of treatment, and the efficiency of the treatment. The growth of urban areas and the concentration of industries around them is increasing the concentration of complex chemical pollutants from commercial and industrial operations. Chemical pollutants create a nuisance because of the inability of existing treatment processes to remove them effectively. Present treatment methods now remove only 75 to 90 percent, each, of the suspended solids and the biochemical oxygen demand. Little of the total nitrogen and phosphorus content is removed. As communities become more densely populated and intensely industrialized, higher degrees of waste treatment will be required to limit the amount of pollutants being discharged to natural streamflow.

e. Structural Land Treatment Solutions. Land treatment structures enable the maximum yields of the land and water resources to be realized without deterioration of these resources. The application of land treatment structures would have significant effects on reducing runoff, erosion and sediment in a watershed. Principal structural methods employed in land treatment are tile fields, open ditches, sewers, grading, tree lining, riprapping, crop cover and terracing.

3. NONSTRUCTURAL METHODS

a. General. Nonstructural methods of meeting water and related land needs can be categorized into various legislative, educational and managerial

programs. Nonstructural methods are developed from organized research and planning efforts that lead to specific plans consisting of control and restrictive measures which are implemented through informational and enforcement procedures. The more familiar nonstructural solutions to water and related land resource problems are described in the following paragraphs.

b. Legislative Programs. Water and related land needs can be met through the legislative powers of the Federal, State and local governments. Through these powers, laws and regulations can be adopted that insure that the health, safety and welfare of the public are maintained. In addition, adequate but strict procedures should be established to enforce these programs. The more urgent legislative programs needed to solve water and land resources problems are in establishing water quality standards, regulating flood plains and preserving lands for future public development. Water quality standards can be adopted for water resources based on various uses of these resources. As specific locations of water resources are planned for designated uses, either for the present or future, the water quality standards adopted for the uses can be applied to the locations. This will insure that the quality standards of the water resources are protected and maintained for their designated uses. Flood plain regulations can be an effective measure in relieving problems associated with floods. Flood plain use can be regulated by various means, such as encroachment lines, zoning ordinances, subdivision regulations and building codes. Flood plain regulation does not attempt to reduce or eliminate flooding, but rather to minimize potential flood damages. This is accomplished through regulating the development that can take place within the flood plain. Flood plain regulation also insures the safekeeping of property for the public health and welfare and the best use of the available land.

c. Educational Programs. Educational programs provide valuable assistance in understanding problems associated with resources. Educational programs can be classified as an informative rather than a corrective or a preventative measure in solving resource problems. Many problems associated

with resources can be avoided through well-planned educational programs. These programs can be developed and implemented by Federal, State and local governmental entities or by private organizations. Educational programs could be carried out through meetings, printed material, and radio, film and television media. The personal aspect of meetings provides significant assistance in relating in laymen's terms the complex problems associated with development of resources to the local officials and the general public. Printed material such as books, pamphlets, and magazine and newspaper articles also provide a means of educating. These materials would provide a concise, factual and informative presentation of all aspects of the various problems and solutions associated with resources. Another important phase of effective educational programs is utilizing radio, film and television. The large exposure to the public by these means offers the greatest potential in resource education. The major value of an educational program is that it aids the public officials and the general public to understand the problems associated with resources and to become more appreciative of the complexity of these problems. An informational program also provides for a more informed public which would be more responsive to plans developed by the Federal, State and local governmental entities given the responsibilities of resolving resource problems.

d. Management Programs. An effective resource management program is characterized by its well-planned objectives understood by all, a balanced organization, sound procedures, qualified personnel, adequate resources, performance standards, and an effective appraisal of results proceeding from the program. The purpose of a resource management program is to develop the most efficient organizations, methods, and procedures that will produce the optimum return on the available resources. Institutions that can implement resource management programs are at all levels of Federal, State and local governments as well as private organizations. The more familiar land and water, conservation, regulatory and monitoring resource management programs are described in the following paragraphs.

(1) Agricultural Conservation Management. Agricultural conservation management programs encourage land and water uses that will yield

improved and continued maximum returns without deterioration of the resources to the people of the Basin and the Nation. The use, treatment and management of all lands in the Basin have pronounced effects on the water resources, as land is the first increment on which an upland watershed program is developed. Conservation-needs studies place emphasis on accelerating the application of land measures to reduce runoff, erosion, and sediment production. Reducing erosion to acceptable limits will reduce the accumulation of sediment in channels. Contour farming, conservation, rotation, and pasture improvement techniques should be applied to those lands suited for agriculture. Cleared land which is not suitable for cultivation or pasture should be reforested to improve the watershed and the aesthetic appeal of the area. Land treatment practices include drainage of excess water, which allows more efficient use of the land. Other conservation measures that are designed to protect, develop, and improve the agricultural, forest-land and recreational assets of the Basin, and increase overall farm efficiency, will be included. These measures will be implemented through the Soil Conservation Districts in cooperation with the Soil Conservation Service.

(2) Forest Conservation Management. Forested land has a significant conservation effect on the water resource. Forest conservation measures include, but are not limited to, forest fire control, tree planting, protection of forest land from grazing, control of erosion on logging roads and skid trails, hydrologic cultural treatment and protection from overcutting.

(3) Fish and Wildlife Conservation Management. If increasing the habitat base for certain species proves impractical or uneconomical, increased opportunity for hunting and fishing can be provided by management manipulation. Production and harvest techniques can be applied to increase hunting and fishing opportunity. For example, levels of use on existing public hunting or fishing areas can be increased by "put and take" stocking.

(b) Methodology. Valley preserve areas consist of the water surface and designated land areas on one or both stream banks. Designation of these land areas is based on needs, present land development, land blocks, and natural boundaries. The significance of each of these factors is described in the following:

1. Needs:

a. Recreation: Needs are expressed in terms of acres required to support the various recreation components such as camping, swimming, and picnicking. Recreation needs are diversified so that the size of the valley preserve developed is not restrictive. Large areas may be developed to encompass all aspects of recreation, while only a few acres are necessary to develop a single-use area such as a roadside park, or, where the topography is suitable, a ski slope or sled slide.

b. Fish and Wildlife: Needs are expressed as user-days. This unit is not easily converted to required acres for an entire basin. Needed acreages for both hunting and fishing are dependent upon the intensity of development and the size of the facility. Hunting areas require rather extensive tracts of land for efficient management. The smallest Grand River basin area presently managed by the State is about one square mile; the largest approaches 25 square miles.

2. Present Land Development:

a. Subdivision: Subdivisions that occupy land areas adjacent to streams would be allowed to remain within the valley preserve area, but the dwellings would require flood proofing. Flood proofing of existing subdivisions would consist of first floor levels being above a prescribed flood level, basements equipped with adequate pump facilities, and access roads above a prescribed flood level. These dwellings would also be required to connect to municipal sewage treatment facilities. Isolated dwellings or groups of two or three dwellings would be obtained outright or relocated.

(4) Recreation Resource Management. Recreational resource management programs consist mainly of providing water and land resources and facilities for outdoor recreation use. These programs range in scope from providing roadside picnic tables to an intensively developed lake and adjacent land area. Most local communities and counties, and the State have established well defined recreation programs. These programs are administered and directed by planning agencies of the governmental units of those political subdivisions. The sole purpose of these planning agencies is to develop recreational facilities for the enjoyment of the public.

(5) Valley Preserve Management. Valley preserve management is a nonstructural program of providing for the effective multiple-purpose use of water and related land resources. The valley preserve management program is not a new concept of meeting water and related land needs. However, its application has been restricted to comparatively much smaller areas than an entire river basin. Typical examples of small valley preserve developments are found throughout the United States. Most valley preserves are well-developed flood plain areas devoted to meeting the recreational needs of metropolitan areas. Most of the developments have very high use rates, and the immediately adjacent areas usually are well developed with quality residential units and offer excellent aesthetics. Management programs previously mentioned have rather well defined programs and established practices. However, the application of a valley preserve program to an entire river basin requires that a detailed description be presented of the program. The description consists mainly of defining the assumptions and procedures used in applying the program to a river basin.

(a) Assumptions.

1. Management of valley preserves will be through direct control of these areas by either local governments, the Michigan Grand River Watershed Council, State agencies, or Federal Agencies.

2. Present policies and criteria hindering development of a valley preserve program may be changed so that recommended valley preserve development can be implemented.

b. Highways: These boundaries would be utilized whenever possible. They serve the purpose of providing access to the valley preserve area. Highway development also enhances land development for residential use as a result of a valley preserve across the highway. Those residents existing in groups along highways (strip housing) would not necessarily be purchased. It is intended that the remaining home sites would be allotted a sufficient depth. These homes would also be enhanced as a result of the valley preserve area in their backyards.

c. Land Blocks: Land blocks would be used in designating areas when available. This would avoid excessive legal and technical costs incurred in subdividing land blocks.

d. Natural Boundaries:

1. Topography: Where steep banks are encountered and needs do not exist or are satisfied through development of another area, only adequate right-of-way areas would be obtained. These right-of-way areas would be reduced to minimal widths through city limits. It is intended that the right-of-way areas would be utilized as hiking trails.

2. Mineral Pits: Mineral pits would remain in production, but would be required to provide adequate sewage and pollution treatment facilities for all production features, processes, and operations.

(c) Constructive Management of Valley Preserves. Elements of the management program of valley preserves consist of developing the water and related land resources for the intended use and the continual maintenance of these resources. Proper development of valley preserves consists of providing appropriate facilities for the intended functional use of the area while preserving the natural setting of the area. Facilities required for each designated activity are briefly described below.

1. Recreation:

a. Swimming: Beach areas will be provided where bank slopes and topography are suitable for their development. Hydraulic structures such as jetties, groins, or check dams may be constructed to develop and maintain these facilities. In addition, public facilities for showering, locker rooms, rest rooms, and public access and parking areas will be developed. These facilities will also be equipped with adequate safety features. It is noted that these facilities may also be used for ice skating use during the winter months under proper safety conditions.

b. Boating: Public access, parking and launch facilities will be provided for designated boating areas. In addition, proper sanitation facilities will be provided for boat users. Each site will also be provided with proper safety equipment.

c. Camping: Areas designated for camping will be provided with public access with adequate service features such as separable mobile and non-mobile sites. Each area will be served by adequate sanitation facilities. In addition, the mobile camp site will be also equipped with electrical outlets. Each site should have access to facilities for family participation activities, such as volleyball, shuffleboard and horseshoes. Each site will be provided with proper emergency equipment against health, fire and natural hazards.

d. Hiking: Hiking facilities will consist of public access and parking areas. Trails will be designated as to functional use such as bike, mobile, horse, sled and nature. Trails will be properly marked for direction as well as being informative. Sanitation and first aid equipment will be provided at designated areas within reasonable distance of all trail locations. Brochures will be made available indicating trail functions and points of interest.

e. Picnicking: Public access and parking areas as well as proper sanitation facilities will be provided. Adequate outdoor cooking grills and tables will be provided. Adequate facilities should also, where possible, provide for development of family recreation activities such as softball, volleyball and horseshoes.

2. Hunting and Fishing:

a. Hunting: Facilities will consist of adequate public access to the hunting area. Brochures will be provided indicating public lands available, referenced by significant landmarks. An attempt will be made to retain the natural development of these areas.

b. Fishing: Adequate public access sites with boat launching and parking facilities will be provided. Areas will also be designated as shoreline fishing sites. It is anticipated that proposed coho salmon introductions in the Lower Grand River will generate a great need for public access and fishing sites.

3. Aesthetics: Intangible benefits associated with the aesthetic values of a valley preserve would be derived as a result of providing an extensive area of water and related land resources that has been developed for the main purpose of meeting the recreational needs of the Basin while preserving and restoring the water and related lands to their natural state. The aesthetic values would be experienced by those who dwell in the immediate valley preserve area as well as those who are traveling through the Basin.

(d) Benefits:

1. Tangible: These benefits would be those realized by flood control, recreation and fish and wildlife users. They are derived as a direct use of the water and related land resources. Methods are presently available to evaluate these benefits.

2. Intangible: The intangible benefits derived from implementing developments of a valley preserve would be significant. Land enhancement, flood damage prevention, water quality enhancement, and

aesthetic values comprise the greatest amount of intangible benefits. Each of these factors is briefly described hereinafter.

a. Land Enhancement: Land enhancement would increase significantly as a result of adjacent lands being closely located to recreational areas while remaining reasonably close to urban areas. Studies made at the University of Kentucky on effects on property tax evaluations of development of reservoirs indicate that for tax areas lost through governmental ownership, the land valuation per acre increased on the remaining portion of the county such that the ability of local governments to extract tax revenues was retained. After a short period of time, tax revenues were substantially increased by economic growth due to the reservoir. This study also provides a methodology for evaluating the effects of developing the water and related land resources of an area on the property tax revenues.

b. Flood Damage Prevention: Flood damage prevention intangible benefits would be derived as a result of preventing industrial, commercial, and residential development from taking place within the area subject to periodic flooding.

c. Water Quality: Water quality intangible benefits would be derived by preventing the increased erosion of soil, salt, and oil which accompanies flood plain urbanization. A methodology is not known at this time to evaluate these effects.

d. Aesthetics: Intangible benefits associated with the aesthetic values of a valley preserve would be derived as a result of providing an extensive area of water and related land resources that has been developed for the main purpose of meeting the recreational needs of a basin while preserving and restoring the water and related lands to their natural state. The aesthetic values would be experienced by those who dwell in the immediate valley preserve area as well as those who are traveling through the Basin.

(6) Water Conservation Management.

(a) Industrial: Water of adequate quality in sufficient quantity is of great importance to industry, because it now uses, and will continue to use, more water than any other segment of the economy. There are five basic techniques of water conservation in industry. First, where high quality fresh water is not required by the manufacturing processes, saline water or treated sewage effluents could be used.

A second important method of conserving water is the reduction of water waste. Meters could be installed to show how much water is being wasted when manufacturing processes are stopped. Leaks in pipelines could be determined by this method. Another important method by which water waste can be reduced is to provide manual or automatic valves to stop the flow of process, cooling or rinse water when a machine is not in use. Another effective method of reducing water waste is to install thermostatically controlled valves on machine cooling systems. Instead of water streaming through, thermostats can retain the water within limited temperature ranges.

Third, the procedure of reusing water over and over again for the same process can serve to reduce consumption. However, the procedure of recycling produces changes in the quality of water because of the evaporation of the water in heat dissipation. Additional treatment, therefore, becomes necessary.

Fourth, multiple reuse of water may result in reduction of water usage, for example, it could involve the reuse of water in a sequence where initial cold water is used where low temperature cooling is required, after which the warmer water effluent is directed to processes where warmer water may be used. Another aspect of multiple use of process water is to introduce it to the cleanest materials first, and then to the dirtiest materials last.

Fifth, industry has found that it can reclaim water formerly going to waste by reconditioning the water by simple screening and sedimentation processes. The development of new techniques for reconditioning waste waters will, in many cases, reduce the strength of industrial wastes.

(b) Agricultural: Another use of fresh water is for irrigation. Conservation of water supplies through more efficient use would involve (1) control of water losses in storage and transport, including seepage and water use by non-beneficial vegetation; (2) improved efficiency of water application and distribution; (3) improved water application control structures and measuring devices; (4) use of more accurate methods of soil moisture determination; and (5) proper timing of irrigation for efficient water use and drainage control. General farm, livestock and rural-farm domestic water waste could be reduced by more careful use.

(c) Municipal: A larger percentage of the pumpage by municipal water systems is used domestically. Efficient industrial water use is covered in an earlier paragraph. Leakage from underground public water supply mains is a continuing and recurring problem that needs to be corrected periodically. An aggressive detection and control program could reduce undergound leakage and thus increase the amount of water for public use. Changes in household plumbing would conserve water. Older household toilets require approximately twice as much water in flushing as the newer models. Lawn watering varies widely with precipitation, temperature and habit. Regulation of lawn irrigation is another method of conserving water.

(7) Regulatory Management Programs:

(a) Flood Plain Zoning: A preventative method of reducing flood damage is the controlled use of the flood plain. Designated flood ways could be zoned for the primary purpose of passing floodwaters and other limited land uses that do not conflict with the primary purpose. Flood plain ordinances provide legal regulatory controls which serve to coordinate land usages with the potential flood hazard. Other measures included in flood plain management are prevention of channel encroachment, reconstruction of existing structures or floodproof construction in the area subject to flooding, and evacuation of the flood plain. Zoning to provide for retention of certain lands for agricultural uses should be encouraged.

(b) Land Management Zoning: Local zoning ordinances must be encouraged to prevent development which would noticeably impair the aesthetic and recreation values of the streams and inland lakes. Water resources are also polluted by sources other than man. Intensive private development along streams and lakes causes severe deterioration of water quality. The preservation of areas having outstanding fish and wildlife resources will be considered. Pristine areas of certain streams, together with selected wetlands and other ecologically and biologically unique areas of value to the student, fish and/or wildlife manager, or the public in general, should be preserved from degrading development.

n (8) Monitoring Management Programs:

(a) Flood Forecasting and Warning Systems: Flood forecasting and warning systems can be established which will notify flood plain occupants when flooding is imminent. This will enable people to remove portable property above the anticipated flood level, or to remove goods out of the flood plain, reschedule operations, and do other things which would reduce damages and losses which might otherwise accrue from flooding.

(b) Stream Quality Monitoring Program: A water quality monitoring program would enable data to be collected on a continuous schedule. This program will aid in informing the local officials and the public of water quality problems and also enable sources of water quality problems to be located and corrected.

(c) Land Use Monitoring Program: Monitoring of land use provides the assurance that regulatory measures established to control land use are effective. This would be accomplished by reconnaissance of lands and informing the appropriate authorities of those violations noted during the reconnaissance inspection.

SECTION VII
SEQUENTIAL APPRAISAL

1. IDENTIFICATION OF LEVEL OR MAGNITUDE OF PROPOSED DEVELOPMENT

a. Scope or Scale: After the initial proposal or nucleus of development of a project has been selected for analysis and its benefits and costs measured, consideration should be given to scales of development greater or less than the selected nucleus. The optimum scale of development should be found for each project. This optimum scale of development occurs when net benefits are at a maximum. Net benefits are maximized when the scale of development is extended to the point where the benefits added by the last increment of scale (i.e., an increment of size of a unit, an individual purpose in a comprehensive plan) are equal to the costs of adding the increment of scale. The increments considered in this way are the smallest increments on which there is a practical choice of ommission from the plan. In all cases the computed plan shall demonstrate that: (1) there is a need for the goods and services produced; (2) total benefits exceed cost; (3) each separable segment or purpose provides benefits at least equal to cost; (4) there are no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan was undertaken.

b. Timing: Since this plan covers long periods in the future, the selection of the time sequence and order of development of projects should be chosen to meet current needs and the needs as they occur. Therefore, plan implementation will be based on current and projected needs and the geographic distribution of these needs throughout the Basin. The plan is broken down into two phases: first, projects recommended to fill the needs to the year 1985; second, projects recommended to fill the needs from the years 1985-2020. However, if the need arises, projects scheduled in the 1985-2020 period may be initiated earlier.

c. Subareas: An essential step in river basin study is the examination and analysis of the physical possibilities for improvement or development of the basin's resources to meet the needs. For example, flood control measures by reservoirs constructed in the upper Grand River basin would do little to alleviate flooding problems in the lower Basin. On the other hand satisfying

the needs for water supply is limited only by the practical aspects of the distribution systems. Thus, problem areas must be related to the geographic distribution of the measures to satisfy their needs.

2. PLAN OF DEVELOPMENT OPTIMIZATION

a. Best Use: Development of the plan should be directed toward achieving the best possible use of the resources employed, taking all pertinent factors into account. The best use of the economic resources required for a project is made if they are utilized in such a way that the amount by which benefits exceed costs is at a maximum, rather than in such a way as to produce a maximum benefit-cost ratio (net benefits maximization principle). However, planning based solely on maximization of net tangible benefits may lead to unsound decisions. Therefore, development of a plan requires consideration of all project effects - favorable and unfavorable, tangible and intangible. For example, a higher degree of flood protection, particularly in urban areas, than is feasible on the basis of tangible benefits alone may be justified in consideration of the threat to lives, health, and general security posed by larger floods. Also, when long-range water needs are foreseeable only in general terms and where alternative means of meeting the needs are not available and inclusion of additional capacity initially can be accomplished at a significant savings over subsequent enlargement, such consideration may justify the additional cost required. Thus, project formulation studies in the development of the optimum plan will include an analysis of sufficient combinations of scale, function, and timing of development to encompass, and identify within reasonable limits, the project or plan which will provide the maximum net tangible benefits, with full consideration of intangibles.

b. Appraise Alternatives: This analysis, first, will be based on preliminary appraisals of the worth and cost of the individual projects acting as independent units. Then a number of alternative plans of development designed essentially to satisfy the needs of the Basin with regard to the type of need and the timeliness of their satisfaction will be formulated.

A complete, yet preliminary, appraisal of the economic worth and cost will be made for each alternative plan under consideration. These appraisals will serve as the basis for selecting from several plans, a single basic plan to satisfy the needs with the least investment of resources and funds. The chosen plan shall then be refined. Each element proposed for multiple-purpose development, requiring both long-term and short-term storage, will be evaluated over a range of sizes and storage allocations to adjust the project dimensions and storage allocations for maximized net benefits at individual sites. Where single-purpose projects are included they shall be maximized. Finally, all elements of the plan will be arranged chronologically to assure their necessary balance and timeliness to satisfy the needs as they occur.

SECTION VIII

ENGINEERING DEVELOPMENT CRITERIA AND APPROACH

1. INTRODUCTION

Water is an essential element for the existence of life; the water resource is limited as to quantity and quality. The conservation and effective utilization of the Nation's water and related land resources demand that engineering work be of high caliber in order that an optimum plan be developed for the Basin. The best engineering techniques using available resources are to be used. With these facts in mind, the study group established general engineering criteria for physical and economic guidance in developing the plan for the Basin. The engineering criteria formulated for use in the study, which permit logical composition and analysis of plans under consideration, are classifiable into three categories: hydraulics and hydrology criteria, design criteria, and economic analysis criteria. Since a wide variety of problems, objectives and conditions will be encountered, the intensity of planning and investigations will also vary to provide sufficient engineering planning to arrive at sound solutions. The intensity of planning will be based on complexity, size, cost and importance of the project. Using the techniques of inventorying, analyzing, correlating, and balancing the physical and economic factors, a comprehensive plan will be developed for the Grand River basin.

2. HYDRAULICS AND HYDROLOGY

a. Weather - Climate may be defined as a summary of all the weather that a specified area has experienced from day to day over an extended period of years. Unusual weather conditions will occur during this averaging time period and will be given particular attention by the study group. Precipitation shall be studied. Records of rainfall have been tabulated for an adequate period of time and will be used as the major determining factor for all hydraulic projections within the Basin; permeability, transpiration, and evaporation characteristics will be incorporated with

the precipitation records to compute runoff data within the Basin.

b. Collection and Transmission - Water is collected and then transmitted to retention basins; this process occurs both above and below ground level.

(1) Stream flow: The study group will determine and use the base flow, normal flow, flood flow, and low flow characteristics of the above flows to be determined; base flow is that flow which will always exist in a water course and is not necessarily directly dependent upon precipitation; normal flow is that flow which exists in a water course under usual conditions; flood flow is that flow which causes damage to real property; low flow is that flow occurring during the arid part of the year. All future designs for control of the river or stream will be dependent upon the stream flow to be expected.

(2) Ground water: The study group will make determinations on ground water availability both as to water quality and quantity. Included in this study will be rock formation locations, infiltration data, replenishment data, and the location of principal aquifers in the Basin.

c. Water Quality - In the comprehensive study water quality is defined as that water which is suitable for the purpose intended, such as for water supply both domestic and industrial; recreation both for total body contact and partial body contact; fish, wildlife and other aquatic life; agricultural such as livestock watering, irrigation and spraying; and commercial such as navigation and hydroelectric power. Water for these uses will be measured by various parameters of content both as to dissolved and suspended constituents. The study group will note the established or desired water quality for each use category and will attempt to suggest possible remedies for those locations which are lacking in water quality for a particular use.

d. Floods - Floods are a natural occurrence and can not be prevented, but by the use of proper control measures damage can be minimized. General criteria utilized in the plan formulation process for flood control measures is contained in the following. Records of previous flood stages have been tabulated and will be used to determine probable flood

frequencies; flood frequency data will then be combined with damage records to determine stage damage frequency relationships. Probable floods will also be computed using known historic, and possible climatic, conditions; extent-of-probable-flood criteria will be used by the study group in appropriate calculations for design of structures. The study group will then apply the determined flood conditions to specific situations.

e. Effects of Man-Made Structures - The study group will relate existing and proposed man-made structures to the hydrology of the Basin. Structures having an effect on water quality and on hydraulic characteristics that will be considered are dams, levees, fills, wells, bridges, industrial complexes, sewage treatment and agricultural practices.

3. DESIGN

After careful consideration of the hydrology of the Basin the study group will research possible measures, both structural and nonstructural, for developing a plan where there is determined an unbalance between needs and supply for a purpose. Structures such as dams and reservoirs will take into consideration the possibility of multiple-purpose uses, while structures such as levees and floodwalls will generally be limited to a single-purpose use. Surveys and designs will be of sufficient detail and extent using appropriate methods and procedures to make acceptable cost estimates and to assure proper functioning and production of anticipated benefits.

a. Dams and Reservoirs - Dams will be considered in conjunction with the reservoir area and the impounded water. Their design will be dictated by usage and purpose using accepted engineering techniques. Specific design considerations to be reckoned with are: the spillway design, to accommodate a given frequency flood; leakage and drainage; erosion and resulting sedimentation; approaches and causeways; stream control during construction; and availability of dam construction materials.

The climate, topography, and other physical characteristics of the Grand River basin dictate that only small-to-medium size dams will be considered for the Basin. Sizing of maximum reservoir storage capacities

and non-storage capacities will be based solely on needs, availability and economic considerations. Physical limitations of each site will be determined from available U. S. Geological Survey mapping in the 15 minute and 7-1/2 minute series. This will be supplemented by more detailed mapping whenever necessary.

b. Levees and Floodwalls - Levees and floodwalls will be a definite consideration especially in urbanized areas. Factors that the study group will note for design of levees are protection against a particular frequency flood, freeboard, interior drainage, erosion, and minimizing the collection of debris. Pumping stations to handle interior drainage present a major economic consideration and the study group will take special note of this.

c. Channel Improvement - Channel improvement will be considered by the study group when certain conditions present themselves. Channel improvement is accomplished by widening, deepening, straightening, and smoothening of a water course. Where flooding occurs improvement will be recommended when an improved hydraulic behavior of a channel is possible and construction can be economically justified.

d. Agricultural Improvements - The level of protection to agricultural lands shall be sufficiently high to encourage the most profitable use of such land for sustained agricultural production within the capabilities of the soil for the type of crops expected to be grown. The remaining flood risk after installation of the project should be no greater than other risks that deter the fullest use of land in accordance with its capability.

4. ECONOMIC ANALYSIS

The study group will complete a detailed economic study on each project meriting such study. The estimated project first cost will be prepared for each such project considered, using generalized unit costs based upon latest prices for similar items of work in the area where the project is located. The total investment in a construction project will include the costs of: lands and clearing; construction items, such as relocations, excavation, concrete, and structural steel; interest during construction; engineering and design; and contract supervision, inspection and administration. A contingency allowance of up to 25 percent will be used and added to the

subtotal of the land and construction costs. The costs of engineering and design will be shown as a percentage of the construction cost, including contingencies. The percentage used will be based on experience and cost records of similar comparable projects. The cost of supervision, inspection and administration will be shown as a percentage of construction costs including engineering and design. Average annual cost estimates will then be prepared, including interest and amortization cost on investments, operation and maintenance, and repairs and replacement. Benefits for each purpose in the project shall be provided by the agency normally responsible for that use or purpose. The designs and estimates will be refined to the degree of accuracy necessary to determine whether, by comparison of average annual costs and benefits, (a) project being investigated has a benefit-cost ratio of over one and could be included in the Plan, and (b) comparison is possible of alternatives to determine ranking of projects in order of ability to satisfy objectives at minimum overall costs.

SECTION IX

SELECTION TECHNIQUES

1. GENERAL

Selection of all schemes and each particular site shall take into account the prior established regimen of the river and shall implement the Economic Base Study, Appendix O, of this report. The optimum plan of development is the desired result. A determination of what is optimum is a function of the standards by which it is judged and in this study, this will be consistent with the principles of project formulation contained in Section IV of this appendix. The Plan shall be judged by consistent standards during each successive evaluation and appraisal and thus each proposed plan will be compared on the same basis.

2. SINGLE-PURPOSE PLANS

Single-purpose plans have been developed for each basic water need by those agencies most informed with the individual needs. Each plan with its single-purpose need is presented in Appendices G thru M, inclusive, wherein the single-purpose analysis was made of water uses, demands and needs which are judged by the standards appropriate in that field. Optimization in one field was obtained in each single-purpose plan. Each plan reflects the minimum standards for satisfying a need, and obtains economic optimization through benefit-cost analysis. The selection of a single or best plan is a process of elimination of less desirable plans through analysis of each plan and appraisal of each alternative. The basic steps in this appraisal were:

a. Check out each plan for physical feasibility.

b. Screen out marginal plans based on available data.

c. Develop rough cost estimates for all plans under consideration.

d. Develop rough benefit estimates for all plans under consideration.

e. Compare the cost-benefit relationship and eliminate plans that obviously will not achieve a favorable ratio. Full consideration was given to the intangible and secondary benefits of each plan.

f. The promising plans are refined in all aspects such as; physical detail, cost and benefit estimates, and review of all favorable and unfavorable side effects, so as to converge toward the optimum.

g. Reconsider all prime schemes previously eliminated. This included varying the size or scale of development so as to yield maximum benefit at least cost for each site or plan tested.

h. Make finaladjustments and apply all intangible benefits to arrive at the single-purpose plan of development where the maximum net return at minimum cost is established.

3. MULTIPLE-PURPOSE PLANS

The selection of multiple-purpose plan of development followed generally the steps outlined above for the single-purpose plans utilizing the data developed in the single-purpose schemes. The Basin was first divided into the same subareas as those used in the single-purpose plans, and for each water use, the existing conditions, minimum needs and maximum needs are tabulated by subarea and then locations selected for each area where these needs can be met. The needs in each area are compared with the availability of water to meet the needs, and then follows a system of screening and selection for each study period (to 1985, and 1985 to 2020) using these steps:

a. By review of needs for each subarea, determine the sites physically and hydrologically most suitable for multiple-purpose development.

b. Review each single-purpose requirement, by subarea, and translate all requirements into the better sites. Summarize the various single-purpose requirements that will satisfy the needs at the sites and utilize reasoned choices when there is a conflict in use.

c. Make preliminary cost estimates for development of each site.

d. Establish preliminary benefit estimates, in dollars, for each demand and/or objective being considered. Table P-4 summarizes reservoir uses and the demand units for each use. Negative benefits as well as positive benefits are to be included. Estimated values for secondary and intangible considerations shall also be established so that quantitative

and economic appraisals may be tabulated for each site. In this way the significance of secondary and intangible considerations are noted for this and later evaluations.

e. Choose those sites in each subarea with the best benefit-cost ratios and which meet, or most nearly meet, the functional requirements of the single-purpose objectives.

f. Repeat steps c thru e above in more detail and as often as necess until the very best plan is determined for each subarea. When the subare plans are put together they constitute a scheme of development for the entire Basin.

g. From this point, study only Basin-wide schemes or plans of develo ment, rather than individual subarea plans.

h. Initiate more detailed study of each previously determined best site with the objective of maximizing the development. This can be accomplished by using different combinations of uses and scope. Cost and benefit data will be computed for each scheme using the principles in the Separable-Costs-Remaining-Benefits Method.

i. Review each proposed development to ascertain that:

(1) The incremental benefit of each use equals or exceeds the incremental cost of that use.

(2) All proposed uses are compatible with each other and with study objectives.

(3) Any social or political factors which might preclude construction have been recognized.

(4) The plan could be implemented under current Federal or Mich legal authorities, or under those authorities as modified in accordance with this study's recommendations.

j. Tabulate costs and benefits for each development and evaluate and select the most promising combinations.

k. Refine study costs, benefits and operational plans for the selec sites. Prepare and evaluate alternatives that reflect the special needs intangible considerations and any other side effects.

Table P-4

PROPOSED DATA INPUTS FOR MULTI-PURPOSE PROJECT FORMULATION USING ONLY TANGIBLE CONSIDERATIONS

Reservoir Use	Demand Unit	Benefit Unit
Water Supply Municipal Industrial Irrigation Rural-Domestic	CFS (or equivalent) over a time scale	Dollars
Water Quality (minimum flows in channels)	Minimum CFS (or equivalent) over a time scale	Dollars
Flood Control (by reservoir holdouts)	Reduction in CFS at a point downstream	Dollars
Navigation (minimum stages in a reservoir)	Acre-feet in reservoir plus CFS needed to maintain stage.	Dollars
(minimum flows in channels)	Minimum CFS (or equivalent) over a time scale	Dollars
Recreation (water related)	Acres of water surface or associated lands over a time scale	Dollars
Fish and Wildlife (recreational) (non-recreational)	Acres of water surface or associated lands over a time scale	Dollars
Hydroelectric Power	CFS (or equivalent) over a time scale	Dollars
Agricultural-Water Management Drainage	Acres	Dollars

l. Determine the prime developments and further refine each plan and its related economic data to arrive at a plan of development wherein net return is maximized.

m. Reconsider all prime plans and alternatives previously eliminated and make final adjustments including any adjustment for competing uses of water.

n. Recommend the best plan.

Grand River Basin Study

APPENDIX Q
ALTERNATIVE PLANS

Prepared Under Supervision of the
GRAND RIVER BASIN COORDINATING COMMITTEE
Chairmanship: U. S. Army Engineer District, Detroit

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THE ABOVE LISTED PLATES, PLATES Q-I THRU Q-64, APPLY TO PLAN A AND NOT TO PLAN B.

SECTION I

THE PLANNING PROCESS

1. INTRODUCTION

The Grand River Basin Comprehensive Water Resources Planning Study was directed by a Coordinating Committee, composed of Federal, State, and local agencies, under the chairmanship of the Department of the Army. Serving jointly with the Department of the Army were the Federal Departments of Agriculture; Commerce; Health, Education, and Welfare; the Interior; and Transportation; the Environmental Protection Agency; the Federal Power Commission; the Great Lakes Basin Commission; and the State of Michigan. The Michigan Grand River Watershed Council also participated in the planning process. This Section describes briefly the planning process used to develop recommended programs for the Basin. Many of the steps and procedures described briefly in this Section are discussed in more detail in Appendix P - "Basin Plan Formulation Criteria."

2. TERMINOLOGY

The terminology employed in Appendix Q does not correspond in every particular to the terminology used in the Plan of Investigation or in the Appendices A through P. As improvements to the terminology were offered throughout the course of the study, they were adopted when it was felt that they contributed to precision of thought or to clarity of presentation.

3. PLANNING OBJECTIVES

Wise use of the Basin's water and related land resources requires that adequate consideration be given to all identifiable needs for national income, for regional development, for environmental enhancement, and for the well-being of people. The significance of these objectives is discussed in the following sub-paragraphs.

a. National Income Objectives. National income measures the Nation's output as the aggregate earnings of labor and property which arise from current and future production. The increase in national income attributable to a project or plan is the measure of its contribution to this objective. These gains result from water quality control; navigation facilities; power; flood control; land treatment;

drainage; watershed protection; outdoor recreation and fish and wildlife opportunities; and provision of water supplies for domestic, municipal, agricultural and industrial uses.

Gross national product (GNP) is the measure customarily used to express the current or projected national output. It measures the Nation's output as the market value of goods and services produced. Gross national product equals national income plus certain non-factor costs, chief of which are indirect business taxes and capital consumption allowances.

Personal income measures the current income received by persons from all sources. It differs from national income mainly by the inclusion of transfer payments and the exclusion of corporate profits. Personal income is generally coordinate in significance for economic analysis with national income and gross national product and has the advantage of being measurable on a geographic basis. Moreover, a close and generally constant relationship between personal income and GNP has prevailed over the long run. It is on the basis of this relationship that the income received by persons offers a link whereby the rate of economic growth in the Nation can be tied to that of an area in the economic projections prepared by the Office of Business Economics and the Economic Research Service (hereafter called OBERS).

In the OBERS projections the Nation's real gross national product is currently projected to increase 4.0 percent per year over the next 50 years. Accompanying this growth, employment would increase at 1.5 percent per year to maintain the goal of "full" employment. Direct employment in the efficient production of goods and services from water and related land resources development helps to meet this goal as does related economic activity that puts to work otherwise unemployed or underemployed workers or other resources.

In OBERS projections productivity as measured by production per worker is expected to increase at a rate of approximately 2.5 percent per year, thus contributing to the expected growth in the gross national product. Development of water and related land resources increases

the productivity of natural resources and may increase the productivity of labor and capital used with these resources. Increases in crop yields, enhancement of land use, expansion in recreation use, and peaking capacity for power systems are examples of direct increases in productivity from water and related land development that contribute to national income. Additionally, there may be further national income gains from putting otherwise unemployed resources to work in related activities and from taking advantage of economies of scale and other externalities.

Droughts, floods, and fluctuating water supplies cause disruption in economic activity. Reduction in direct economic losses through water and related land resources projects will reduce losses to other dependent activities and contribute to economic stability and steady flows of income.

b. Regional Development Objectives. The regional development objectives embrace several related components such as (1) increased regional income, (2) increased regional employment, (3) improved regional economic base, (4) improved income distribution within the region, and (5) improved quality of services within the region. Income gains in the region would include national income gains accruing to the region. Not all national income gains arising from a project in a region will necessarily accrue to that region.

Where national policy and goals seek to bring about an improved geographic distribution of economic development through expansion of economic activity in a region, the efforts of projects or program activities toward achieving such goals will be considered as regional development benefits. These regional development objectives are closely related to the well-being objective of personal income distribution.

The "region" relevant to this report is the Grand River Basin.

c. Environmental Objectives. Environmental objectives include the conservation, preservation, creation, or restoration of natural, scenic, and cultural resources in order to enhance or maintain the

quality of the environment. These objectives are closely allied to all efforts to conserve natural resources, including (1) the preservation or enhancement of aesthetic areas including open and green space, wild rivers, lakes, beaches, shores, wilderness areas, estuaries, or related areas of unique natural beauty; (2) the protection of areas of archaeological, historical, or scientific value; (3) the protection or improvement of water quality including the control of pollution from all forms of waste, drainage, and heat; and (4) the prevention of erosion and the restoration of eroded areas, with particular emphasis on the treatment of watersheds, mined areas, and critical erosion areas including gully, streambank, roadside, and beach erosion.

A major consideration of environmental objectives is to conserve natural resources so that they will be available when needed and so that the freedom of choice by future users will not be impaired.

d. Well-Being Objectives. In addition to national income, regional development, and environmental objectives, other well-being objectives consider the personal, group, and community effects of the project or program activity. Since some of these well-being objectives have a location impact, there is a close relation to regional development objectives. Included are such objectives as security of life and health, national defense, personal income distribution, and interregional employment and population distribution.

Security of life and health are enhanced by reducing risk of floods or other disaster to human life and by reducing the hazards to health associated with water development and use.

National defense objectives are served by providing critical water supplies, goods, or transportation requirements or by providing needed reserve capacities and protection against interruption of the flow of goods at the time of critical need.

Objectives of personal income distribution are determined by national policies that specify arrangements for distribution of project benefits and costs among groups of beneficiaries.

The distribution of population and employment over the Nation is of national concern and the effect of projects on such distribution should be indicated so that such effects can be related to national policy considerations.

4. USES OF WATER AND RELATED LAND

a. Uses of Water. Water is used for many purposes. Domestic uses of water include drinking, cooking, sanitation, fire protection, and air conditioning. Industrial uses of water include its use as an important ingredient in numerous finished products; its use as an agent for cooling, for removing impurities, and for preparing solutions; and its use in diluting and removing industrial wastes. Agricultural uses of water include irrigation, rural domestic, and livestock use. Water is also used as a source of power, a medium of transportation, an agent for waste purification, a setting for outdoor recreation, and a habitat for fish and wildlife.

b. Uses of Water-Related Land. The usefulness of water provides a strong stimulus to develop the lands adjacent to water. The adjacent lands are often highly productive for agricultural and forestry purposes. The transport capability of surface water makes adjacent lands valuable as sites for urban and industrial complexes. The great demand for water-oriented recreational experiences requires the development of large tracts of water-related land. Large areas of land are also used in constructing projects that control and regulate the water resource.

5. PROBLEMS ASSOCIATED WITH WATER AND RELATED LAND RESOURCES.

Problems associated with water are due to deficiency, excess, or misuse. Water deficiencies affect municipal and industrial water supply, public health, recreation, agriculture, fish and aquatic life, wildlife, power, navigation, and waste assimilation. Excess water causes flood damages, drainage problems, soil erosion, and sediment damages on urban, agricultural, and forest land. Misuse of flood plains can lead to unnecessary flood damage; misuse of streams for waste assimilation and for cooling water, in excess of their capabilities for receiving waste products or heat, can lead to deterioration of

stream quality; misuse of agricultural and forest lands can cause erosion, sediment, pollution, and drainage problems; and inadequate channel stabilization can cause erosion and sedimentation. Preservation or acquisition of lands designated for water resource development can be difficult and costly if the lands are located near the urbanized areas which generate the needs.

6. METHODS OF SOLVING THE PROBLEMS.

Planning for the comprehensive development of a basin's resources to meet identified needs and to prevent misuse of resources requires a thorough inventory and evaluation of the basin's resources. Solutions of resources problems fall into two categories: solutions by means of structures; and solutions by non-structural means. Any resource development that meets more than one need is considered to be a multi-purpose development, in contrast to the single-purpose development which meets only one need.

a. Nonstructural Methods. Nonstructural means of meeting water and related land needs consist of various programs of legislation, education, management and research. The objectives of these programs can be either single-purpose or multiple-purpose. A summary of possible nonstructural solutions to water and related-land resources problems is presented in Table I-1.

(1) Legislative Programs. Legislative programs designed to meet resource needs derive from the authority of State and local governments to establish and enforce laws and ordinances to ensure the health, safety, and welfare of the public. Programs that may be implemented by these governmental agencies are: development of quality standards for the water resources; control of the sediment production resulting from urban and transportation development areas; regulation of the urban and industrial development in flood plains; and a program to ensure preservation of lands designated for future public development.

(2) Educational Programs. Educational programs should be directed toward local officials and the general public. Educational programs can be implemented through organized efforts of Federal, State, and local planning agencies, which should utilize all educational media: classes, radio, newspapers, books, pamphlets, and television. In addition, publicly supported organizations interested in resources can provide valuable assistance.

TABLE I-1
SUMMARY OF NONSTRUCTURAL SOLUTIONS TO WATER AND RELATED LAND-RESOURCE PROBLEMS

1. Water Supply

   (a) Land use and management for water yield
   (b) Artificial recharge
   (c) Land acquisition
   (d) Institutional constraints

2. Flood Damage Reduction

   (a) Floodplain zoning
   (b) Flood forecasting - warning - evacuation systems
   (c) "Flood proofing"
   (d) Floodplain acquisition
   (e) Review of new construction proposals
   (f) Land use and management to control runoff

3. Related Land

   (a) Land use zoning and regulation
   (b) Tax relief
   (c) Land acquisition
   (d) Obstruction or hazard removal
   (e) Purchase of easements or development rights
   (f) Land and water management

4. Erosion and Sedimentation Control

   (a) Land use and management
   (b) Stream bank stabilization
   (c) Land acquisition
   (d) Land use zoning and regulation
   (e) Tax relief

5. Water Quality

   (a) Land use zoning and regulation
   (b) Land treatment and management to control runoff
   (c) Removal of waste solids
   (d) Standards and regulations
   (e) Legal measures - enforcement

6. Environmental Quality

   (a) Land use zoning and regulation
   (b) Land acquisition
   (c) Recreational easements
   (d) Urban forestry
   (e) Tax incentives
   (f) Land use and management

(3) Management Programs. Resource management programs should be directed by efficient organizations that utilize available techniques and procedures in planning and developing the best use of resources. Water and related land resources management programs should be developed for agricultural, forest, and recreation land, flood plains, urban and built-up areas, and valley preserves.

(4) Research Programs. Research is an additional non-structural method of meeting future water needs. With respect to power generation, for instance, improved cooling techniques for steam-electric generation, or possible beneficial uses of heated discharge waters, might be alternative solutions to low flow augmentation. Improved cooling techniques might permit maintenance of appropriate oxygen levels in the stream discharged into, and thereby reduce the need for low flow augmentation. Identification of beneficial uses for heated discharge water might suggest alternative sites for power plant location.

Regardless of what the specific problem may be, applied-research programs may reveal alternative courses of action which would not otherwise be evident. An effective applied research program should be goal-oriented, i.e. should be unequivocally directed toward attainment of a solution for the particular problem at hand, and should take cognizance of relevant basic research and of parallel applied-research efforts that may have been conducted elsewhere.

At least as important as occasional or even frequent formal research activities is cultivation of a "research mentality," the willingness to entertain and pursue imaginative alternatives to the more conventional techniques of satisfying identified needs. This habit of thinking should underlie the selection of even the most conventional type of solution, i.e., the solution should be proposed only after all viable alternatives have been given adequate consideration.

b. Structural Methods. Water and related-land resources needs are met structurally by projects which provide physical means of controlling resources. Projects may range in size and scale from large multiple-purpose reservoirs to single-purpose bank stabilization by rip-rapping. A summary of possible structural solutions to water and related-land resources problems is presented in Table I-2. Inspection of this table indicates that most structural means serve only one purpose, but that reservoirs can provide structural solutions for many combinations of resource problems.

TABLE I-2
SUMMARY OF STRUCTURAL SOLUTIONS TO WATER
AND RELATED-LAND RESOURCE PROBLEMS

1. Drainage
   - (a) Ditches
   - (b) Grading
   - (c) Pumping
   - (d) Sewers
   - (e) Tile drains

2. Erosion
   - (a) Check dams
   - (b) Levees
   - (c) Rip-rap
   - (d) Diversions
   - (e) Grade stabilization structures

3. Fish and Wildlife
   - (a) Fish ladders
   - (b) Hatcheries
   - (c) Reservoirs

4. Flood Damage Reduction
   - (a) Channel improvements
   - (b) Diversion
   - (c) Levees
   - (d) Reservoirs

5. Irrigation
   - (a) Ground water facilities
   - (b) Reservoirs
   - (c) Surface water facilities

6. Navigation
   - (a) Channel improvements
   - (b) Harbors
   - (c) Locks
   - (d) Reservoirs

7. Power
   - (a) Cooling ponds
   - (b) Cooling towers
   - (c) Reservoirs
   - (d) Thermal electric plants

TABLE I-2 (Cont'd)

8. Recreation

   (a) Basic facilities
   (b) Reservoirs

9. Water Quality

   (a) Ground water facilities
   (b) Improved treatment
   (c) Reservoirs
   (d) Surface water facilities

7. CONSIDERATION OF ALTERNATIVE PROJECTS AND PROGRAMS.

The process of plan formulation consists essentially of an analysis of alternative solutions to identified resource problems. Selection of projects and programs is made on the basis of economic feasibility and social acceptability. In many instances the selection can be made without detailed analysis. An alternative project or program is considered to be significant if it possesses a reasonable degree of economic feasibility or social acceptability. An alternative project or program is considered to be not significant if it fails to meet the requirements of economic feasibility or social acceptability. A reasonable degree of economic feasibility of a project or program requires a sum of market valued and nonmarket valued benefits judged to be at least comparable to the cost of the project or program. A reasonable degree of social acceptability is present if a project or program promotes the well-being or the interest of the people of the community, the region or the Nation.

SECTION II

PROBLEMS AND NEEDS

1. INTRODUCTION

a. General. At the commencement of the Comprehensive Grand River Study, public hearings were conducted in the Basin. These hearings provided the public an opportunity to identify problems and indicate their needs and interests for water resources development in the Basin. Specific desires for improvements by local interests were indicated as follows: navigation; flood control, and flood plain information studies; agricultural drainage and flood control; land resource management; irrigation; water supply; management of retired hydro-power reservoirs; water quality control, low flow augmentation to assimilate treated sewage, sewage disposal, pollution controls, and detergent pollution problems; fish and wildlife studies, conservation, and water quality for wildlife; recreation, parkways; dredging and filling inland lakes; future growth and industrial expansion; and diversion of water for essential purposes.

Section II of Appendix Q is not an attempt to offer a solution to the problem of meeting these needs, but is simply an attempt to present a straightforward picture of (1) the needs as they exist today, and (2) a projection of these needs for the years 1980, 2000, and 2020.

A review of Basin resource problems, supplies, and demands indicates a necessity for resource development programs. Resource problems, supplies and demands for the Basin have been identified by the reports prepared by the participating agencies. Resource needs have been estimated for agriculture, forestry, flood control, fish and wildlife, low flow augmentation for water quality, and navigation. Resource needs are described in detail in subsequent paragraphs of Section II.

The urgency in solving the complex problems involving the use of water and related land will become increasingly more critical as the human population and its water needs grow. The agricultural uses of water are expected to increase during the study period, with emphasis being placed on row crop irrigation and land drainage. The water needs for nonagricultural uses will become even more important. Water needs for recreation, domestic household,

and industrial uses will increase significantly, particularly as more and more land is converted to these uses.

(1) Agricultural Uses. The major agricultural activities that use water directly (livestock production, rural domestic household activities, and crop irrigation) involve the handling of both ground and surface water supplies. Ground water sources are more efficient and dependable, but become more expensive to use if water tables recede. Better utilization of both types of supplies is needed in order to satisfy the expected increases in crop irrigation, rural domestic, and livestock uses. Improved water retention methods need to be found to combat seasonal shortages at critical times of the growing cycles.

(2) Nonagricultural Uses. Meeting the water needs and demands of an expanding urban population has become one of the major challenges in the Basin. In some portions of the Basin, water is being taken from the ground water supply faster than it is being replenished. Greater use must, therefore, be made of the surface and impounded waters, along with developing better water reuse methods.

Industrial needs for water will increase as the economy of the Basin expands and prospers. Although the extent of water degradation by industrial uses is small when viewed on a basin-wide basis, critical problems are created in local situations where waters are returned to their river beds or watercourses in a super-heated condition. Some manufacturing industries add harmful liquid effluents from their processing operations directly to the water. Effective regulations on water use are needed to help guide industries in the proper use of this resource.

b. Market-Valued Needs. A market-valued need is a quantitative measure, convertible into monetary terms, of the difference between the supply and demand of a resource to be used for a specific purpose. Market-valued needs can usually be associated with specific locations or areas to which programs are applicable.

c. Nonmarket-Valued Needs. Nonmarket-valued needs have real value in satisfying human desires but normally cannot be measured in monetary terms. They are normally based on the social, aesthetic, or environmental quality desires of the population.

2. WATER SUPPLY.

a. Municipal Water Supply. In 1963 there were 54 communities in the Grand River basin served by community water supply systems. These facilities served an estimated population of 543,000 and supplied water at the average rate of 89 million gallons per day (mgd). Of this total, approximately 45.5 mgd were supplied for domestic, public, and commercial uses and 43.5 mgd were supplied for industrial use. Table II-1 summarizes municipal water use data for the Grand River basin.

TABLE II-1
TOTAL WATER INTAKE - MUNICIPAL WATER SYSTEMS, GRAND RIVER BASIN (1963)

Source	Population Served	Water Intake (mgd)
Surface Water	214,000	35
Ground Water	320,000	54
Total	534,000	89

Municipal water demands for the major water service areas and projections to the years 1980 and 2020 are presented in Table II-2. The projections are based upon considerations of population growth, anticipated industrial expansion, and projected industrial water use efficiency.

TABLE II-2
MUNICIPAL WATER DEMANDS IN 1963 AND PROJECTIONS
TO 1980 AND 2020

Service Area	Source of Water ***	Population Served (1963)	1963 Demand (mgd)	1980 Demand (mgd)	2020 Demand (mgd)
Grand Rapids *	G, S, Lake Michigan and Grand River	252,000	40.7	68	131
Lansing **	G	127,000	22.4	40	112
Jackson	G	55,000	10.5	16	30
Grand Haven	G	11,000	3.3	5	11
Greenville	G	7,450	1.4	2	4
Hastings	G	7,320	0.8	1	3
Ionia	G	6,700	1.0	2	3
St. Johns	G	5,900	1.0	2	3
Grand Ledge	G	5,770	[illegible]	1	2
All Others	-	58,000	7.3	28	61
Basin Total		534,000	89.0	165	360

* Includes Wyoming, Grandville, and East Grand Rapids
** Includes East Lansing and Lansing Township
*** S = Surface water source, G = Ground water source

b. Self-Supplied Industrial Water. Based on data provided by the Bureau of the Census in a special tabulation for the Federal Water Quality Administration, it has been determined that the major demand for self-supplied industrial water in the Basin is the Grand Rapids, Lansing, and Jackson areas as shown in Table II-3. Projections contained in Table II-3 were developed following consideration of anticipated increases in industrial output and water use efficiency.

TABLE II-3
SELF-SUPPLIED INDUSTRIAL WATER DEMANDS IN
1959 AND PROJECTIONS TO 1980 AND 2020

Service Area	1959 Demand (mgd)	1980 Demand (mgd)	2020 Demand (mgd)
Grand Rapids	5	8	14
Lansing	2	3	6
Jackson	6	9	14

c. Forest-Based Industrial Uses. At the present time, sawmills require very little industrial water. In 1962, there were approximately 30 million board feet of lumber produced. The total combined water use of these present mills is and will continue to be a very small portion of the total industrial demand.

Presently, there are no primary manufacturing pulp mills in the Basin. The water needs of the secondary manufacturing paper mill, located at Rockford in Kent County, are projected to double by 2020. It now uses one million gallons per 24 hours of operation.

d. Rural Household and Livestock. Total water demands or requirements for rural domestic and livestock use in the project years are made up of three basic components: (1) water needs for all livestock consistent with the sales of livestock and livestock products; (2) water demands by the farm family and hired farm workers and their families; and (3) water to be used for the preparation of chemicals and pesticides for general farm use.

Water requirements for these uses represent the summation of totals for each class of livestock or domestic need under various assumed uses and use rates for the three projection years. It is assumed that water needs for livestock and rural domestic farm uses will be generated in areas of adequate ground water supplies. Farm operators would not knowingly set up an enterprise combination requiring large amounts of water in an area with inadequate natural supplies.

Under the assumptions used in this study and reflected in the data on Table II-4, the 1960 need for water was 6.1 billion gallons. Family water use in the home accounted for 46 percent of the total and the consumption by dairy cattle in the production of milk also required a large quantity of water.

Rural home and livestock total water demands are expected to increase to 6.2 billion gallons in 1980, then 6.9 in 2000, and nearly 9.0 in 2020, the latter being some 45 percent above the 1960 estimated use level. Although family water use rates rise continually over the study period, the reduction in numbers of people is sufficient to cause a downward trend in both the absolute water need and the proportion this item comprises of the total. One-fourth of all water requirements in 2020 are for family use.

TABLE II-4
ESTIMATED 1960-2020 GENERAL FARM, LIVESTOCK AND RURAL-FRAM
DOMESTIC WATER REQUIREMENTS 1/

Grand River Basin, Michigan

Item	Annual Use 1960	1980	2000	2020
	(Million Gallons)			
Cows 2/ Milk	1,104.2	1,066.2	1,360.1	1,727.6
Dry Cows	93.5	89.7	101.3	117.6
Young Stock	335.9	335.9	379.3	440.2
Dairy Cleaning	26.2	84.0	189.7	220.1
Dairy Sanitizing	105.0	125.9	189.7	220.1
Liquid Manure Handling	-	4.2	23.7	55.0
Sows	23.8	33.9	55.7	69.2
Pigs 2/	76.3	114.2	187.7	241.0
Wallow	21.2	51.9	72.7	48.2
Clean-Sanitizing	-	62.3	174.4	231.4
Fogging-Cooling	-	26.0	72.7	192.8
Laying Flock 4 gal/	-	-	-	-
100, & Young 1 gal/	-	-	-	-
100 2/	19.7	16.4	20.8	8.3
Egg Washing	3.9	3.3	4.2	1.7
Clean-Sanitizing	.4	.5	.9	.5
Spraying-Cooling	-	3.3	8.3	3.3
Beef Cows and	-	-	-	-
Replacements	75.3	112.2	219.3	348.5
Cattle & Calves 2/	351.6	408.1	657.8	968.2
Clean-Sanitizing	1.1	5.6	12.0	15.9
Turkeys 2/	35.2	49.3	71.9	100.0
Clean-Sanitizing	.5	1.3	3.3	6.8
Spraying-Cooling	-	4.5	13.1	18.3
Sheep & Lambs 2/	23.1	18.5	20.7	26.5
Ewe Flock	41.8	33.8	43.0	54.3
Clean-Sanitizing	.2	.9	1.8	2.2
Family Water Use	2,833.3	2,259.3	2,199.1	2,168.1
Car & Truck Wash	55.6	122.2	120.6	99.0
Lawn & Garden	148.2	244.5	402.0	495.0
Swimming Pool	-	18.4	101.2	202.5
Hired Workers & Family	620.5	728.2	759.2	722.7
Mortality	-	-	-	-
Sheep (5-15%)	3.0	1.7	1.5	1.4
Beef (3-5%)	1.9	2.2	3.2	5.1
Dairy (3-5%)	23.3	17.9	15.2	17.6
Pigs (5-15%)	5.7	5.9	6.8	6.0
Vegetables	7.4	10.4	8.2	9.4
Fruit	85.8	82.4	67.9	80.2
Samll Fruit	3.1	6.9	6.1	8.3
Potatoes	6.1	2.7	2.8	4.3
Total	6,132.8	6,154.6	6,894.6	8,937.3

1/ Adapted from Water Systems Analysis to Meet Changing Conditions, Agricultural Engineering Department, Michigan State University, Infromation Series 152, File No. 18.35.

2/ Product marketed.

3. LAND RESOURCES

a. Irrigation. The amount of agricultural land which will be irrigated is expected to increase during the study period. The amount of water required to irrigate these added acres will also increase.

In 1964, 11,370 acre-feet of water (approximately 3,705 million gallons) were used to irrigate 21,167 acres. Most of the irrigated land was planted to truck crops, fruit, and potatoes. It also included some non-agricultural irrigation of golf courses, parks, and cemeteries.

The pattern of irrigation was estimated through use of an economic budgeting procedure which identified the extent of irrigation to be practiced by Basin farmers to efficiently meet their share of the market needs. The total projected acreage of fruits and vegetables needed under irrigation in 1980 is nearly 17,000 acres (Table 11-5). The demand for irrigated acreage of these crops is projected to be 23,000 in the year 2000 and 32,000 in 2020. Vegetable crops account for the major acreage likely to be irrigated.

Another result of the economic budgeting model indicated that the only general field crop with an economic potential for irrigation under average conditions in all three projection years is potatoes. Soil Group 4 shows the greatest potential for potatoes. The total projected acreage of irrigated potatoes needed will be 4,000 in 1980, nearly 4,600 in 2000, and 6,200 in 2020.

Projections show a potential for 28,050; 36,682 and 48, 044 acres under agricultural irrigation for years 1980, 2000 and 2020, respectively, which would require 25,570; 31,209 and 38,834 acre-feet of water on an average annual basis.

b. Land Treatment. Proper management of the land, its use and treatment is needed for the general economic growth and betterment of the Basin. A land treatment program that will provide for continuous utilization of land resources to satisfy current needs and at the same time conserve this resource for future needs is essential.

Economic projections of crops, yields, and costs of production contained in this study are based on adequate land use, treatments, and management. Failure to follow adequate practices would, of course, substantially reduce projected yields and increase costs of protection. Therefore, a

Table II-5 Acreage of Certain Irrigated Specialty Crops by Soil Associations, with Acre-Inches of Water Required, for 1960 and Projections to 2020. 1/

Grand River Basin, Michigan

Soil Management Groupings	1960 Vege-tables	1960 Fruit	1960 Small Fruit	1980 Vege-tables	1980 Fruit	1980 Small Fruit	2000 Vege-tables	2000 Fruit	2000 Small Fruit	2020 Vege-tables	2020 Fruit	2020 Small Fruit
4				7,496	14,025	2,277	8,140	17,306	3,096	9,184	20,810	4,287
5				4,278	13,436	2,320	4,568	16,641	2,977	5,105	19,296	3,974
7				17,804	--	--	20,164	--	--	23,414	--	--
Total Acres Grown	16,381	20,432	1,568	29,578	27,461	4,597	32,872	33,947	6,073	37,703	40,106	8,261
Percent Irrigated				43.52	7.24	42.27	51.39	11.21	45.56	59.58	15.18	48.86
4				3,262	1,015	962	4,183	1,940	1,411	5,472	3,159	2,095
5				1,862	973	981	2,347	1,865	1,356	3,042	2,929	1,942
7				7,748	--	--	10,362	--	--	13,950	--	--
Total Acres Irrigated				12,872	1,988	1,943	16,892	3,805	2,767	22,464	6,088	4,037
Ave. Application in Acre-inches				7.78	3.81	8.60	7.71	3.81	8.26	7.64	3.81	7.98
4				25,378	3,867	8,273	32,251	7,391	11,655	41,806	12,036	16,718
5				14,486	3,707	8,437	18,095	7,106	11,201	23,241	11,159	15,497
7				60,279	--	--	79,891	--	--	106,578	--	--
Total Acre-inches Applied				100,143	7,574	16,710	130,237	14,497	22,856	171,625	23,195	32,215

1/ Source: Unpublished irrigation study, Economic Research Service of United States Department of Agriculture, 1966.

program of land treatment to reduce runoff, erosion, and sedimentation must be carried out.

The Michigan Inventory of Soil and Water Conservation Needs shows projected future acreages of cropland, pasture, forest and woodland that will need conservation treatment. From the total of 2.1 million acres determined in 1958 to be in need of treatment by 1980 should be subtracted the amount of land treatment applied during the 10-year period, January 1958 through June 30, 1968 to determine the existing unfilled needs.

TABLE II-6
PHYSICAL LAND TREATMENT NEEDS

Land Use	Expected Acreage Use 1980 2/	Acreage Needing Treatment 1980 2/	Acreage Treated 1958-68 3/	Remaining Area Requiring Treatment by 1980
Cropland	1,863,800	1,316,000	568,000	748,000
Pasture	269,800	184,000	35,000	149,000
Forest	643,600	490,000	19,000	471,000
Miscellaneous	388,700	107,000	4,000	103,000
Other 1/	392,500	0	0	0
Total	3,558,400	2,097,000	626,000	1,471,000

1/ Includes suburban built-up areas and water surface acreage.

2/ Based on 1958 Conservation Needs Inventory

3/ Applied from January 1958 to June 30, 1968.

(1) Crop and Pastureland. The Conservation Needs Inventory in 1958 identified 1,316,000 acres of cropland in 1980 having one or more conservation problems and requiring conservation treatment in order to help meet future basin crop needs. Over one-third of the original needs have been treated in the last ten years. Nearly 750,000 acres remain in need of treatment. Such treatment should be geared specifically toward significantly reducing wind and water erosion on 196,000 acres, excess water on or in 301,000 acres,

and unfavorable soil conditions on 233,000.

About 184,000 acres were identified by the Conservation Needs Inventory as anticipated pastureland, that needed one or more pastureland treatment measures in 1958. There have been 35,000 acres sucessfully treated in the past decade. The acreage remaining in need of treatment is 149,000. The major needs are the establishment or re-establishment of vegetation on 75,000 acres and the improvement of vegetative cover on 54,100 acres of pastures. A total of 17,800 acres of wet areas need removal of excess water and protection of vegetative cover. Treatment measures to control soil erosion are also needed.

(2) Forest and Woodland. Although the 1958 Conservation Needs Inventory identified 397,000 acres of forested land as needing one or more conservation measures, the present acreage projected for forested land use in 1980 in need of treatment is 471,000. The net gain resulted when the expected addition of idle crop and pastureland acres to forest land uses overbalanced the acreage receiving treatment measures in the past decade.

Restocking or restoration to a productive condition will be needed on 139,800 acres of commercial forest land and idle open lands presently non-stocked or poorly stocked by 1980. Protection from overcutting and excessive logging damage is needed on 346,200 acres. Grazing control is needed on 91,800 acres. Hydrologic stand improvement is needed on 107,200 acres.

Fire protection on forested lands is presently being handled adequately by the Michigan Department of Natural Resources in cooperation with the Forest Service. In order to meet future protection requirements, there is a need for additional brush-type wildfire equipment in the volunteer fire department units and for additional prevention programs and training in wildfire suppression techniques.

More trees and shrubs should be planted and protected in urban and suburban areas. More technical assistance and consultative and educational services are required in developing urban forest and conservation and improvement practices for environmental enhancement.

(3) Nonagricultural Land. It is estimated that 103,000 of the acres projected to be classified as miscellaneous land in 1980 will need grass and tree planting to control runoff and erosion.

Landowners will encounter increased pressure to convert their

agricultural and forested lands into urban-industrial uses, such as highways, airports, and urban-suburban developments.

Land use change has an important effect on the rainfall-runoff relationship. The trend to urban and "paved" land uses in the Grand River basin will diminish late summer low flows, will increase flood hazards after heavy precipitation or snow melt, and will impair recharge of ground water systems.

The orderly conversion of crop and pastureland should be encouraged to prevent haphazard urbanization and excessive reductions in the better agricultural land.

More intensive use of cropland and woodland acres for recreation purposes is expected. Multiple use of such Basin lands when feasible for hiking, picnicking, hunting, and other natural resource-based recreation activities is necessary and desirable. Water oriented outdoor recreation is an important part of the people's attraction to agricultural and forested settings. Although many locations have adequate resource conditions, the facilities need to be developed, improved, or made more available for public use. Long-range planning and direction is needed to help meet both the increasing future private and public recreation needs.

c. Drainage. Approximately 635,000 acres of land are affected by excess soil moisture. There is an economic potential for drainage that will reduce on-farm production costs on 177,700 acres of cropland by 1980. There will be an economic potential for drainage of cropland on 133,700 acres in 2000, and 156,600 acres in 2020 (Table II-7).

Of the total amount needed by 1980, 23,965 acres of organic soil and 47,430 acres of mineral soil can be improved by adequate outlets within the watersheds inventoried in this study designated as having potential for early development (the next 10 to 15 years). The additional acreage of land can be obtained through the use of on-farm and small group drainage facilities.

d. Urban Land Treatment. As the number of people living in metropolitan and suburban areas has increased, the need for natural areas with trees and shrubs has increased proportionately. This has become a severe problem in many areas. Its solution has been complicated by increasing competition for land. Conditions for plant growth have steadily deteriorated because

TABLE II-7

ACREAGE OF CROPLAND REQUIRING DRAINAGE AND HAVING AN ECONOMIC POTENTIAL TO DRAIN 1/

Soil Association	1980	2000	2020
1	25,600	4,000	7,300
2	14,400	35,500	62,000
3	16,400	61,400	55,200
4	74,600	5,900	7,300
5	31,000	0	19,200
6	11,400	0	1,600
7	4,300	26,900	3,700
Total	177,700	133,700	156,600

1/ Drainage has the potential of reducing the overall on-farm cost of producing agricultural crops on these soils from what would prevail in the basin if these soils were left in their undrained state. Costs of providing outlets, where needed, through public expenditures have not been included.

of air pollution, drought, erosion, heat, mechanical hazards, poor soil, and other adverse influences resulting from construction and concentration of use. The loss of trees and shrubs has led in turn to the destruction of environmental values. Trees and shrubs have an ameliorative effect on air temperature; they dampen the harsh sounds of the city; they have beneficial effects on air pollution; they reduce erosion and sedimentation; they protect water supply; and they enhance the beauty of natural surroundings. Many State, community, and private land areas are deteriorating rapidly due to over-use of land, destructive land use practices, and inadequate knowledge of the principles of resource management. Unless a strong program is undertaken to stop the accelerating deterioration of natural environment in and around areas of high density population, the costs of correction will become extremely high. In many cases, correction will become impossible. In order to be successful, public and private programs for planning and managing natural lands within urban areas must embody the proper combination of technical disciplines, careful planning, management, and strong community action.

e. Soil Survey. Agricultural land is under increasing pressure from urban growth and expanding public facilities. The land use decisions which are being made daily require sound planning. A detailed soil survey is basic to the planning process. This inventory of our soil resources shows the location of different soils, describes their physical and chemical properties, and summarizes their limitations for various uses.

Approximately 2,500 acres in the Basin are being converted to urban uses annually. This acreage will nearly double by the year 2020. This scope of development must be based on sound soil information.

At this time, eleven of the twenty counties with acreage within the Basin have soil surveys completed or scheduled for completion. There are no current plans for completing the detailed soil survey in the remaining nine counties. In these areas, the Soil Conservation Service will continue to provide soil surveys to individual landowners for conservation planning. This will not, however, be sufficient to provide guidance for all anticipated land use decisions.

4. NAVIGATION

a. Existing Project, and Terminal and Transfer Facilities.

(1) Existing Project. The existing project for Grand Haven Harbor and Grand River provides for protecting the mouth of the river with piers and

and revetments, 3,569 and 5,549 feet in length on north and south sides respectively; for a channel 23 feet deep, 300 feet wide from that depth in Lake Michigan to a point 1,000 feet inside the pier ends; thence 21 feet deep, 300 feet wide, 2-1/2 miles long to the Grand Trunk Railway Bridge at Ferrysburg with a turning basin 18 feet deep, 100 feet wide, 3,100 feet long to Spring Lake; and a channel in Grand River 8 feet deep, 100 feet wide, and 14-1/2 miles long. The existing project was substantially completed in 1949. A controlling depth of 23 feet is presently available in the entrance channel; 21 feet between the piers and in the river to the Grand Trunk Railway Bridge; 18 feet in the turning basin; 8 feet in Grand River to Bass River; and 18 feet in the outlet from Spring Lake. All project structures are in generally good condition. Total costs of the navigation projects to 30 June 1971 have amounted to $1,283,469 for new work, $6,916,333 for maintenance, and $813,613 for rehabilitation of project structures.

(2) Terminal and Transfer Facilities. The only significant terminal and transfer facilities are located at Grand Haven Harbor. They consist of several wharves used for handling coal, limestone, slag, sand and gravel, petroleum products, fish, and miscellaneous commodities. There is also a car ferry slip which is inactive. Sand and gravel shipping terminals are located near the Bass River at the upstream limit of the existing Federal project. Sand and gravel from these terminals is shipped by barge to Grand Haven. There are no commercial terminals or transfer facilities located at the city of Grand Rapids. For recreational craft there are marinas in the Grand Haven area and numerous landing places along the river. These facilities appear adequate for existing commerce and vessel traffic. If channel improvements are made to permit a significant increase in boating, facilities will be provided as the need arises.

b. Commerce.

(1) General. Future waterborne commerce at Grand Haven Harbor is expected to increase along with an anticipated steady increase in population over the tributary area and future growth in road building, building construction, and industrial expansion. Growth of general industry is expected due to the harbor's geographical location on the west coast of Michigan and its proximity to the industrialized Grand Rapids Metropolitan Area. The expected increase in vessel commerce will continue to consist mainly of receipts of coal and

and limestone and shipments of sand and gravel.

(2) Grand Haven Harbor. The volume of lakewise waterborne commerce through Grand Haven Harbor amounted to 3,328,447 tons in 1970. The greater portion was moved by deep-draft self-unloader type vessels and consisted largely of coal, slag, petroleum products, and limestone receipts along with sand and gravel shipments. During the past 10 years, the commerce of the harbor has varied from a minimum of 2,669,427 tons in 1961 to a maximum of 3,693,175 tons in 1969. the average of the 10-year period, 1961 to 1970, being 3,146,174 tons.

Local commercial interests indicate that the harbor's sand and gravel shipments can be expected to increase. Several reserves presently serving the Great Lakes are near depletion. Sand and gravel shipments should increase by 500,000 tons by the year 1975 as sand and gravel presently shipped from reserves near depletion is replaced by sand and gravel shipped through Grand Haven Harbor. The shipments can be expected to increase annually by about 25,000 tons per year during the period 1975 through 1985. The harbor's limestone receipts can be expected to increase annually by about 5,000 tons through the year 1985. Coal shipments, primarily used in the production of electricity, can be expected to increase by 237,000 tons by 1975 and by 600 tons annually between 1975 and 1985. The Board of Light and Power of the city of Grand Haven has indicated that the capacity of their Island Generating Station will be increased 110 megawatts by 1975 requiring a large increase in coal usage. It is expected that by 1985, annual inbound vessel traffic will include 485,000 tons of coal and 183,000 tons of limestone. It is also expected that outbound self-unloading vessel traffic will include 2,010,000 tons of sand and gravel.

(3) Grand River Intraport. Commerce on the Grand River is limited to the shipment of sand and gravel from the deposits located at the mouth of the Bass River to the harbor at Grand Haven, a distance of 14-1/2 miles. All of this commerce was moved by shallow-draft barges, two barges per tow, and during 1970 consisted of 728,594 tons of sand from the area known as "the sag" and 1,060,160 tons of unprocessed gravel from the reserves near the mouth of the Bass River. After processing, 373,119 tons of gravel were shipped by lake vessel and the remaining 687,041 tons were distributed by railroad and truck. All of the sand was reshipped by lake vessel. The total volume of intraport commerce on the Grand River amounted to 1,613,057 tons in 1970.

Local sand and gravel interests indicate that intraport shipments to their processing and shipping facilities can be expected to increase. By 1985, it is expected that 2,000,000 tons of gravel will be shipped from the reserves near the mouth of the Bass River to the processing plant. Foundry sand from the sag area is expected to increase to 1,397,000 tons by 1985.

c. Commercial Vessel Traffic. Great Lakes bulk cargo is transported by a fleet of vessels which is undergoing gradual, but deliberate, transformation. The average draft, length, and capacity of the lake carriers is continually increasing. Two factors have accelerated this trend: (1) obsolescence in the present fleet; and (2) the deepening of the Connecting Channels and the major commercial harbors. New vessels, which have been designed to take full advantage of the greater depths, and vessels that have been rebuilt, operate at a lower cost per ton only when loaded at or near maximum capacity.

A study of United States and Canadian flag self-unloading vessels shows that most of the vessels calling at Grand Haven had attainable drafts of over 21 feet, the limiting project depth. As a result they were unable to fill to, or near capacity. The vessels with maximum drafts less than 21 feet probably will soon be replaced with deeper draft, longer vessels. With ships calling at Grand Haven not loading to capacity, economic advantages of cheaper shipping are lost. Deepening Grand Haven Harbor to Great Lakes Connecting Channel depths is necessary to accommodate the existing and future Great Lakes fleets.

Grand Haven Harbor's commerce is expected to increase and consist mainly of receipts of coal, limestone, and sand and gravel. Land and dock sites along the shore, rail facilities, highways, and an improved deep-draft harbor may attract new industry and waterborne commerce. It is expected that the size of deep-draft vessels serving Grand Haven Harbor will increase in the future. The average size of vessels in the Great Lakes bulk cargo fleet has been increasing since World War II and more noticeably in the last ten years. This increase is attributed to the fact that many of the smaller vessels have reached or passed their 50 year life expectancy and greater economies are realized by using larger, more efficient carriers. Completion of the St. Lawrence Seaway and deepening of the Great Lakes Connecting Channels, together with the deepening of major commercial harbors, have served to accelerate this transition. Most new vessels, which have been designed to take advantage of the greater depths now available, operate at a lower cost per ton only when loaded at or near maximum capacity.

It is expected that self-unloaders will continue to carry the harbor's bulk coal, limestone, sand, and gravel commerce. The large tonnage increases expected for these commodities in the future will result in increased harbor traffic, and the need for deeper harbor facilities, to accommodate deep-draft shipping. Shipping companies on the Great Lakes have been retiring or rebuilding their old, small, and inefficient ships at an ever increasing rate. The composition of the fleet of self-unloaders serving the Great Lakes is expected to change during the proposed improvements' 50-year amortization period.

On the Grand River, the present channel dimensions directly limit the size (width, length, and draft) of the barges used in the movement of sand and gravel. Present tows consist of two barges; however, the principal shipping company operating on the Grand River is considering the use of three barges and a tug, bringing the overall length per tow to 585 feet. These longer tows will be able to operate only during periods of high water inasmuch as at other times the longer tows will not be able to make the short bends of the river. The 100-foot width of the present channel does not permit a tow of this length to navigate the ship turns and still remain within the channel lines. Commercial interests have stated that if the channel dimensions were enlarged they would definitely increase the size of their burden and tows. Thus, the nature of future commercial vessel traffic on the Grand River is expected to remain essentially the same as at the present time except that larger barges and tugs and more barges per tow would undoubtedly be used if channel improvements were made. There is little possibility in the foreseeable future of a need for deep-draft commercial traffic on the Grand River upstream of Grand Haven Harbor.

d. Recreational Boating. Recreational boating's rise to popularity has been rapid. In 1958, the year the State first began registering boats, there were 217,553 craft in Michigan. By 1965 Michigan's boating population was about 400,000 and in 1971, it was 487,000. These figures point out the tremendous growth in popularity of recreational boating which has occurred in only a few years' time. That this rapid growth will continue in the future is an opinion shared by all agencies, organizations and persons

concerned with the future of recreational boating.

The optimistic future predicted for recreational boating is based not only on past growth statistics but on increasing future population projections, rising national prosperity which provides the consumer with more money to spend on recreational pursuits, and the trend toward shorter workweeks and more holidays which allow more free time to devote to boating activities. Experience has shown that river and harbor improvements or the construction of new facilities results in an increase in the number of locally-based and transient boats. Another factor which has contributed to overcrowding and congestion at existing river and harbor improvements is the rapid increase in the number of trailerdrawn craft being used. These craft, usually 16 to 22 feet long, have no home port but are generally stored on land at the owner's home or at any other accessible location and transported to and from the harbors and waterways on trailers. They include the popular deckless or semi-deckless outboard-driven craft used in calm weather for short duration cruises and the larger, cruiser-like, outboard-driven craft equipped with a forward cabin and used for longer duration cruises.

Future growth of recreational boating on the Grand River would be severely restricted under existing channel conditions. The Grand River is shoaled and unimproved upstream of the upper limit of the existing Federal project at the Bass River. There are no aids to navigation and the numerous bars, snags and other hazards to navigation make the river dangerous even for local boaters familiar with local river conditions. However, if the river were improved there is little doubt that it would be used extensively by locally-based transient, and trailer-drawn craft. The highly populated Grand Rapids and Lansing areas provide the demand and support for recreational boating facilities.

5. ELECTRIC POWER

a. Present Stage of Hydroelectric Development. There were eight hydroelectric projects in the Power Region as of 31 December 1970, representing a total installed capacity of 8,695 kW. This was less than two percent of the region's 1970 installed capacity. These projects produce an average of 27.7 million kWh annually at an average capacity

factor of 36 percent. Table II-8 lists these projects with pertinent data for each. All of these power plants are small, and the majority were constructed at least 30 years ago. It is anticipated that the older plants will be retired or possibly redeveloped as conditions warrant, principally on the basis of physical condition and high operating cost. Since the effect of hydroelectric generation is small, future retirements, if any, will not materially affect the region's projected power supply.

b. Future Electric Power Needs.

(1) Prospects for Growth. Increased electric power load growth can naturally be expected to accompany population growth and economic expansion, but the electric utility industry has historically exceeded these growth rates. A progressively higher standard of living would come from a reduction in the cost of electric energy.

In addition to its efforts to lower costs, the electric utility industry should intensify its efforts to make its facilities acceptable to the public. This involves air pollution, public concern about nuclear plants in congested areas, and beautification features that may require underground distribution and possibly even underground transmission. Furthermore, the industry is faced with increasing costs of right-of-way in fast growing urban areas. Larger capital costs can also be expected for the provision of cooling towers and cooling ponds where an adequate water supply is not available.

Based on past trends, current operation, and announced future plans, the existing and projected electric power requirements for the Power Region are given in Table II-9. The projection of future power requirements to 1990 are based on estimates prepared by Regional Advisory Committees composed of representatives of the electric power industry in cooperation with the Federal Power Commission (FPC). These estimates are part of the FPC's current program to update the 1964 National Power Survey Report and to extend the period of study to 1990. The region's electric requirements are estimated to increase throughout the period of study, but at a decreasing annual rate. By 2020 the growth rate is estimated to be about three percent per year.

TABLE II-8

GRAND RIVER BASIN POWER REGION
EXISTING HYDROELECTRIC POWER PLANTS - 1970

Project Name	River	Owner Class 1/	Owner	Drainage Area Sq. Mi.	Gross Head (ft.)	Installed Capacity (kw)	Average Ann. Energy (1000 kwh)	Avg. Flow Utilized (cfs)	Hydraulic Capacity (cfs)	Initial Operation Year
Cascade	Thornapple	U	Consumers Power Co.	813	28	2,560	8,000	545	1,525	1934
Webber 3/	Grand	U	Consumers Power Co.	1,751	26	3,250	9,100	665	2,085	1907
Moores Park	Grand	P	Lansing Wtr. & Lt. Comm.	758	15	1,000	2,600	330	1,110	1907
North Lansing	Grand	P	Lansing Wtr. & Lt. Comm.	1,230	9	200	1,100	230	370	1936
Irving	Thornapple	U	Mid-State Service Co.	NA	7	600	2,300	625	1,430	1939
Middleville	Thornapple	U	Mid-State Service Co.	NA	12	350	1,500	240	485	1939
Portland	Grand	P	Portland Electric Dept.	1,695	20	375	2,400	230	310	1930
St. Louis 2/	Pine	P	St. Louis, City of	NA	10	360	700	135	600	NA

1/ U - Privately Owned Utility
P - Non-Federal Publicly Owned

2/ Plant located outside River Basin but within Power Region boundary

3/ License pending - Project No. 2566

Table II-9

Grand River Basin Power Region
Existing and Projected Electric Power Requirements

Subarea	Annual Energy (1000 kwh)	Annual Peak (kw)	Annual Load Factor (percent) 1/
	1960		
Grand Rapids	1,908,000	345,000	63.0
West Central Belt	255,000	55,000	52.7
Northeast Fringe	207,000	45,000	52.7
Lansing	1,235,000	240,000	58.6
Jackson	545,000	100,000	62.0
Total Region	4,150,000	785,000	60.2
	1965		
Grand Rapids	2,688,000	485,000	63.5
West Central Belt	364,000	80,000	53.4
Northeast Fringe	292,000	60,000	53.5
Lansing	1,807,000	325,000	63.0
Jackson	779,000	140,000	63.5
Total Region	5,930,000	1,090,000	62.1
	1980		
Grand Rapids	7,515,000	1,315,000	65.1
West Central Belt	1,005,000	205,000	55.5
Northeast Fringe	815,000	165,000	56.0
Lansing	4,865,000	850,000	65.0
Jackson	2,150,000	380,000	64.1
Total Region	16,350,000	2,915,000	63.9
	2000		
Grand Rapids	18,760,000	3,230,000	66.1
West Central Belt	2,510,000	490,000	58.2
Northeast Fringe	2,030,000	380,000	61.0
Lansing	12,140,000	2,090,000	66.1
Jackson	5,360,000	950,000	64.3
Total Region	40,800,000	7,140,000	65.0
	2020		
Grand Rapids	35,630,000	6,055,000	67.0
West Central Belt	4,760,000	900,000	60.2
Northeast Fringe	3,860,000	710,000	61.7
Lansing	23,060,000	3,920,000	67.0
Jackson	10,190,000	1,780,000	65.1
Total Region	77,500,000	13,365,000	66.0

1/ Load Factor - Ratio of average load over designated period to the peak load occurring in that period.

(2) Future Power Generating Equipment by Types. Projections for this study extend beyond four decades into the future. Many factors that will influence future decisions, particularly with regard to nuclear generation, are yet to be resolved.

The type of generating equipment in the Power Region can have an effect on the economics of the region, not only from the standpoint of huge investments involved, but also from the standpoint of the fuel source. In view of the recent rapid advances in the amount of nuclear fueled capacity on order, it is necessary to consider this carefully as a major component of future generating capacity.

Present thinking places the nuclear market in areas where competing fuel costs run about 20 cents per million B.t.u. or higher. This would include the Grand River basin power region. This market must be further qualified, however, to unit-size requirements exceeding 400 to 500 megawatts for investor-owned utilities and 100 megawatts for municipals. A study by Kaiser Engineers for the Atomic Energy Commission indicates that nuclear power reactors in sizes as low as 50 to 100 megawatts could be competitive with municipal financing if ordered in groups of five.

Beyond 1980, and perhaps somewhat earlier, the more advanced types of reactors should be making their appearances, increasing the potential market considerably. Higher capital costs are indicated, but fuel costs have been projected to as low as five cents per million B.t.u.

(3) Location of Thermal Generation. Water availability is a basic criterion in determining the location of thermal generating plants. Fuel can be transported to a plant and electric energy can be transmitted from plant to load center. This arrangement is flexible and an economic balance can be determined between the relative distances of fuel and electrical transportation. Water for cooling purposes, however, cannot be moved any great distance economically. The water resources of the Basin will be an important factor in the generation of electric power.

Conversion of thermal energy to electric energy on a large scale basis is very inefficient at the present time in spite of all the

progress that has been made. An amount of energy, in the form of heat, greater than that which is converted to electric energy is lost in the process. The common practice has been to absorb the greater part of this loss in large bodies of water. Because of the limited streamflow within the Grand River basin, it will become increasingly necessary to use supplemental types of cooling for those capacity additions not utilizing Lake Michigan as a cooling water source. Supplemental types of cooling such as cooling towers and ponds will be possible only at an increase in capital and operating costs.

Based on the considerations discussed and the conditions existing in the power region, estimates of the future power supply in the region were derived as shown in Tables II-10, II-11 and II-12.

Table II-10

Grand River Basin Power Region
Existing and Projected Capacity Requirements and Supply
(kilowatts)

Subarea	Annual Peak	Reserves	Total Required	Hydro Supply	Net Region Import	Thermal-Electric Supply
1960						
Grand Rapids	345,000	39,260	384,260	6,160	291,896	86,204
West Central Belt	55,000	6,177	61.177	5,370	45,117	10,690
Northeast Fringe	45,000	2,125	47,125	360	43,250	3,515
Lansing	240,000	67,930	307,930	1,200	77,230	229,500
Jackson	100,000	-	100,000	-	100,000	-
Total Region	785,000	115,492	900,492	13,090	557,493	329,909
1965						
Grand Rapids	485,000	71,164	556,164	6,160	159,770	390,234
West Central Belt	80,000	4,408	84.408	5,205 1/	65,513	13,690
Northeast Fringe	60,000	1,675	61.675	360	57,800	3,515
Lansing	325,000	95,650	420,650	1,200	104,950	314,500
Jackson	140,000	-	140,000	-	140,000	-
Total Region	1,090,000	172,897	1,262,897	12,925	528,033	721,939
1980						
Grand Rapids	1,315,000	96,800	1,411,800	12,000	611,600	788,200
West Central Belt	205,000	2,000	207,000	16,600	190,400	-
Northeast Fringe	165,000	-	165,000	400	164,600	-
Lansing	850,000	57,000	907,000	1,200	443,000	462,800
Jackson	380,000	-	380,000	-	380,000	-
Total Region	2,915,000	155,800	3,070,800	30,200	1,789,600	1,251,000
2000						
Grand Rapids	3,230,000	306,800	3,536,800	12,000	870,000	2,654,800
West Central Belt	490,000	1,900	491,900	16,600	475,300	-
Northeast Fringe	380,000	-	380,000	400	379,600	-
Lansing	2,090,000	135,800	2,225,800	1,200	1,045,600	1,179,000
Jackson	950,000	-	950,000	-	950,000	-
Total Region	7,140,000	444,500	7,584,500	30,200	3,720,500	3,833,800

1/ Includes 1,600 kilowatts retired 12/27/65

Table II-10 (Cont'd)

Grand River Basin Power Region
Existing and Projected Capacity Requirements and Supply
(kilowatts)

Subarea	Annual Peak	Reserves	Total Required	Hydro Supply	Net Region Import	Thermal-Electric Supply
			2020			
Grand Rapids	6,055,000	611,000	6,666,000	12,000	965,000	5,689,000
West Central Belt	900,000	1,800	901,800	16,600	885,200	-
Northeast Fringe	710,000	-	710,000	400	709,600	-
Lansing	3,920,000	270,000	4,190,000	1,200	1,668,000	2,520,800
Jackson	1,780,000	-	1,780,000	-	1,780,000	-
Total Region	13,365,000	882,800	14,247,800	30,200	6,007,800	8,209,800

Table II-11

Grand River Basin Power Region
Existing and Projected Energy Requirements and Supply
(1000 kwh)

Subarea	Total Energy Required	Hydro Production 1/	Net Region Import	Thermal-Electric Production
		1960		
Grand Rapids	1,908,000	24,560	1,684,547	198,893
West Central Belt	255,000	21,960	201,264	31,776
Northeast Fringe	207,000	1,035	199,492	6,473
Lansing	1,235,000	3,356	396,411	835,233
Jackson	545,000	-	545,000	-
Total Region	4,150,000	50,911	3,026,714	1,072,375
		1965		
Grand Rapids	2,688,000	18,613	466,748	2,202,639
West Central Belt	364,000	16,245	301,066	46,689
Northeast Fringe	292,000	699	283,401	7,900
Lansing	1,807,000	1,005	589,898	1,216,097
Jackson	779,000	-	779,000	-
Total Region	5,930,000	36,562	2,420,113	3,473,325
		1980		
Grand Rapids	7,515,000	47,400	3,496,000	3,971,600
West Central Belt	1,005,000	63,700	941,300	-
Northeast Fringe	815,000	700	814,300	-
Lansing	4,865,000	3,700	2,529,000	2,332,300
Jackson	2,150,000	-	2,150,000	-
Total Region	16,350,000	115,500	9,930,600	6,303,900
		2000		
Grand Rapids	18,760,000	47,400	5,060,000	13,652,600
West Central Belt	2,510,000	63,700	2,446,300	-
Northeast Fringe	2,030,000	700	2,029,300	-
Lansing	12,140,000	3,700	6,068,000	6,068,300
Jackson	5,360,000	-	5,360,000	-
Total Region	40,800,000	115,500	20,963,600	19,720,900
		2020		
Grand Rapids	35,630,000	47,400	5,680,000	29,902,600
West Central Belt	4,760,000	63,700	4,696,300	-
Northeast Fringe	3,860,000	700	3,859,300	-
Lansing	23,060,000	3,700	9,796,000	13,260,300
Jackson	10,190,000	-	10,190,000	-
Total Region	77,500,000	115,500	34,221,600	43,162,900

1/ Based on average annual energy for years 1980, 2000, and 2020.

Table II-12

Grand River Basin Power Region
Composition of the Thermal-Electric Power Supply

	Non-Condensing Type 1/			Condensing Type					
	Internal Combustion			Nuclear			Fossil Fuel		
	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)
1960									
Grand Rapids	93,503	35.2	30,204	-	-	-	105,390	21.4	56,000
West Central Belt	31,776	33.8	10,690	-	-	-	-	-	-
Northeast Fringe	6,473	21.0	3,515	-	-	-	-	-	-
Lansing	-	-	-	-	-	-	835,233	41.4	229,500
Jackson	-	-	-	-	-	-	-	-	-
Total Region	131,752	33.8	44,409	-	-	-	940,623	37.5	285,500
1965									
Grand Rapids	38,694	13.9	31,734	-	-	-	2,163,945	68.9	358,500
West Central Belt	46,689	38.9	13,690	-	-	-	-	-	-
Northeast Fringe	7,900	25.6	3,515	-	-	-	-	-	-
Lansing	-	-	-	-	-	-	1,216,097	44.1	314,500
Jackson	-	-	-	-	-	-	-	-	-
Total Region	93,283	21.8	48,939	-	-	-	3,380,042	57.3	673,000
1980									
Grand Rapids	negligible	-	-	-	-	-	3,971,600	57.4	788,200
West Central Belt	"	-	-	-	-	-	-	-	-
Northeast Fringe	"	-	-	-	-	-	-	-	-
Lansing	"	-	-	-	-	-	2,332,300	57.4	462,800
Jackson	"	-	-	-	-	-	-	-	-
Total Region	"	-	-	-	-	-	6,303,900	57.4	1,251,000

1/ Requires no condenser cooling water.

2/ Capacity Factor - Ratio of average output to maximum capacity.

Table II-12

Grand River Basin Power Region
Composition of the Thermal-Electric Power Supply

	Non-Condensing Type 1/			Condensing Type					
	Internal Combustion			Nuclear			Fossil Fuel		
	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)	Energy Produced (1000 kwh)	Capacity Factor (%) 2/	Capacity (kw)
2000									
Grand Rapids	negligible	-	-	11,650,000	80.0	1,657,300	2,002,600	22.8	997,500
West Central Belt	"	-	-	-	-	-	-	-	-
Northeast Fringe	"	-	-	-	-	-	-	-	-
Lansing	"	-	-	6,068,300	66.2	1,043,200	-	-	135,800
Jackson	"	-	-	-	-	-	-	-	-
Total Region	"	-	-	17,718,300	74.7	2,700,500	2,002,600	20.1	1,133,300
2020									
Grand Rapids	negligible	-	-	29,894,600	61.4	5,546,000	8,000	6.4	143,000
West Central Belt	"	-	-	-	-	-	-	-	-
Northeast Fringe	"	-	-	-	-	-	-	-	-
Lansing	"	-	-	13,260,300	59.9	2,520,800	-	-	-
Jackson	"	-	-	-	-	-	-	-	-
Total Region	"	-	-	43,154,900	60.9	8,066,800	8,000	6.4	143,000

1/ Requires no condenser cooling water

2/ Capacity Factor - Ratio of average output to maximum capacity.

c. Cooling Water Needs.

(1) Factors Determining Cooling Water Needs. At the present time essentially all of the electric power produced by thermal electric generation requires cooling water. Thermal electric plants requiring cooling water now comprise about 92 percent of all the electric generating capacity in the power region and account for about 96 percent of all the energy produced in the region.

Predictions of the patterns of generation beyond 1980 are complicated by several factors, not the least of which is the accuracy of predicted energy requirements beyond that date. The electric power industry is one of the most dynamic industries in the United States, having experienced an annual growth rate of between 6 and 7 percent for a number of years as compared to a somewhat lesser rate for the Gross National Product. The technology of electric generation and supply is changing rapidly with the advent of larger and larger units made possible by rapid load growth, the increasing reliance on extra high voltage transmission, the construction of mine-mouth generation, utilization of unit-type coal trains, and the large increase in the number of scheduled nuclear fueled plants. Also, new methods of generating power which eliminate the conventional heat cycle and thus eliminate the need for cooling water are under active consideration. Among the most promising of these are magnetohydrodynamics (m.h.d.), electrogasdynamics (e.g.d.), thermionic generation, and the fuel cell. Firm planning for future generating capacity is not completed until four to six year before the need becomes apparent. Accordingly, it is to be realized that estimates of consumptive use of cooling water in the years 2000 and 2020 can only be a rough guide to be reviewed periodically as new situations develop. A projection of future water requirements for thermal electric plants has been made on this basis. However, as is evident from subsequent discussion in this report, there are alternatives to the demands for cooling water of good quality. For example, in the event that fresh water is in short supply due to scarcity or imposition of higher priority use, brackish water or sewage effluent can be utilized under certain conditions as a cooling source for thermal electric generation. On the

other hand, with considerable added expenditure, the consumptive use (primarily evaporation) can be almost entirely eliminated by the use of radiator-type closed circuit cooling towers. Also, with the advent of extra-high-voltage (e.h.v.), power can be transmitted over long distances from areas of adequate water supply to water deficient regions.

The principal demand imposed upon water supply by thermal electric generating plants is for condenser cooling water. Boiler makeup water is required for all steam electric plants and some installations also use water for sluicing ashes. These latter two uses have relatively minor effects on water supply and their future magnitudes have therefore not been projected.

(2) Calculation of Cooling Water Needs. Condenser cooling water is considered in two aspects -- first, the amount of water that is required to pass through a condenser in order to produce an acceptable vacuum; and second, the amount of cooling water that is evaporated as a result of the increase in its temperature. Either or both of these could be critical in designing and selecting the site for a power plant.

For purposes of analysis, the method used herein for determining the condenser cooling water requirement of a fossil fuel electric generating station is illustrated by the following sample calculation:

SAMPLE CALCULATION

COOLING WATER NEEDS 1/

Operating Conditions	B.t.u.-k.w.h. 2/	B.t.u.	Percent
Assumed over-all plant efficiency			36
Assumed generator efficiency			97.5
Heat equivalent of one kilowatt-hour		3,413	
Fuel energy required (net plant heat rate)	9,500		
Heat loss from boiler-furnace 3/	950		
Energy delivered to turbine	8,550		
Heat loss from generator 4/	94		
Generator output (net gen. plus 7% plant use)	3,650		
Energy removed in condenser (energy delivered to turbine minus generator output)	4,806		
Energy to be removed by water source 5/	4,900		

Cooling Water Required:

$$\text{Acre-feet/k.w.h.} = \frac{\text{Energy removed by water source}}{\text{Heat Absorption Rate of Water } 6/ \times {}^{\circ}\text{F. temp. change in cooling water}}$$

$$= \frac{4{,}900 \text{ B.t.u./k.w.h.}}{2{,}718{,}144 \text{ B.t.u./ac-ft/}{}^{\circ}\text{F. temp. change} \times \text{temp. change in cooling water}}$$

$$= \frac{0.001803 \quad 7/}{{}^{\circ}\text{F. temp. change in cooling water}}$$

1/ Cooling water required is the amount of water needed to remove heat imposed and is independent of the type of cooling -- flow-through, pond, or tower.

2/ Average United States heat rate in 1966 was 10,547 B.t.u./k.w.h.

3/ Negligible for nuclear plants.

4/ Generator cooling usually part of cooling water load.

5/ Equals condenser load plus generator heat loss.

6/ 1 B.t.u./lb. water/°F. temp. change in water; 2,718,144 lbs. water = 1 ac-ft.

7/ The quantity of cooling water required varies inversely with permitted temperature rise of cooling water.

This shows that, under the assumed conditions shown above, 4,900 Btu of heat is transferred to the cooling water for each kilowatt-hour generated. Experience has demonstrated that the most economical plant designs provide for cooling water temperature rises of 10 to 20 degrees. Based on an average rise of 18 degrees Fahrenheit, it follows from the sample calculation that 100.2 acre-feet of cooling water is required to pass through the condenser for each million kilowatt-hours generated.

Nuclear plants have a higher heat load to dissipate than fossil fuel plants (using current design standards) and thus require about 150 acre-feet of condenser cooling water per million kilowatt-hours assuming an 18°F. temperature rise. Based on an anticipated improvement in nuclear plant operating efficiency it is estimated that the cooling water required will decrease to about 79 acre-feet per million kilowatt-hours by 2020.

(3) Cooling Water Consumptive Use. The primary consumptive use of cooling water is the amount that evaporates due to the increase in its temperature as it passes through the condensing unit. The amount of evaporation will depend on the type of cooling employed: cooling pond or reservoir, wet or dry type cooling tower, or flow-through.

If the cooling water is taken from and discharged back into a pond or reservoir, the heat in the circulated water is dissipated to the atmosphere through convection or induced evaporation. The water that is evaporated is lost to the air, and so becomes a consumptive use attributable to the power operation. Evaporation provides about 64.5 percent of the cooling, in a stationary water body, under average meteorological conditions. Thus, if a power plant contributes 4,900 Btu per kilowatt-hour, about 4,900 × 0.645, or 3,160 Btu per kilowatt-hour is dissipated through evaporation. Since the evaporation of one pound of water consumes about 1,055 Btu, the consumptive use at the pond cooled power plant is 3,160 ÷ 1,055 or 3.0 pounds of water per kilowatt-hour. This amounts to 1.10 acre-feet per million kilowatt-hours generated. This figure will vary somewhat as operating conditions such as efficiency and temperature rise of the cooling water differ from those assumed.

On the other hand, if the cooling water is diverted from a flowing stream and discharged back into the stream after passing through the condensing

unit, the evaporation loss is probably somewhat less than for a cooling pond. The water passing through the condenser in a flow-through system is not evaporated in the condenser, but as a result of the heat load transferred to the water as it passes through the condenser, evaporation takes place when it is returned to its source. For purposes of this study, it is estimated that under average conditions 54 percent of the cooling in a flow-through system is from evaporation. Based on a heat discharge of 4,900 Btu per kilowatt-hour and 54 percent evaporation, about 2,645 Btu per kilowatt-hour would be dissipated by the evaporation of 2.5 pounds of water. This amounts to approximately 0.92 acre-feet per million kilowatt-hours generated. As with cooling ponds, this figure is applicable only under the specified conditions of the sample calculations.

In systems using wet type cooling towers, evaporation accounts for about 85 percent of the cooling, and there are some additional water losses because of spray drift and blowdown loss. The total consumptive cooling tower loss averages about 1.47 acre-feet per million kilowatt-hours generated. As mentioned above, the loss will vary under operating conditions differing from those assumed in the sample calculation.

Nuclear plants currently have a higher consumptive water use than do fossil fuel plants. At the present time they require about 50 percent more than fossil fuel plants. Based on future improvement in nuclear plant operating efficiency it is anticipated that the amount of waste heat dissipated by these plants will be substantially reduced; this will result in a proportionate decrease in consumptive water use.

All of the figures shown above represent hypothetical conditions believed to be about average for the circumstances that could be encountered. Obviously, there are many variables of plant design, location, meteorological conditions, etc., that might cause the figures for cooling water required and loss for a specific plant to vary from those suggested here.

(4) General Conclusion. Under the assumptions outlined, the Grand River Basin Power Region water requirements* and consumptive use are as follows:

* For details of requirements determination see Appendix L - Power.

Description	Year				
	1960	1965	1980	2000	2020
Cooling Water Requirements (acre-feet per year)	131,800	335,900	584,700	1,739,000	3,39[illegible]
Consumptive use (acre-feet per year)	1,800	3,835	6,560	18,940	36,94[illegible]

As indicated by the above, the consumptive use is only a small part (about one percent) of the total water required for cooling.

Although the foregoing indicates the amount of cooling water required and the losses sustained through generation within the Power Region, several qualifying factors should be kept in mind:

(a) The amount of cooling water required and losses sustained for the various periods of study are representative of the entire Power Region. It should be borne in mind that a sizable portion of the thermal capacity would be located outside the Basin drainage area, using Lake Michigan as its water source. Therefore these plants would result in no diversion or depletion of water from the Grand River Basin.

(b) The amount of cooling water required to pass through a plant's condenser is not necessarily equivalent to that diverted continuously from a stream source. This is true only in the case of flow-through cooling; in plants utilizing cooling ponds or towers it is necessary to divert only enough water to replace the consumptive losses.

(c) The water diverted for cooling at generating plants is returned to the stream (except for consumptive loss) and may be reused at downstream plants or for such other purposes as municipal use, irrigation, or industrial use. If the distance between point of plant discharge and point of reuse is not far enough to allow the heat discharged to mix with the streamflow and for the stream to return to an acceptable temperature, it may be necessary to use some type of supplemental cooling to achieve this. Since the water supply may be reused, the adequacy of the supply to support an amount of generation should be determined in relation to a specific plant site.

(d) Alternative means of condenser cooling are available where water supply is scarce or where the aquatic environment would be degraded. The amount of water required, temperature of the discharge, and losses sustained can be varied

at the discretion of designers by changing the design parameters. Two of the most important of these parameters are type of cooling and permissible temperature rise. The type of cooling employed has an important effect on the water consumption, being the greatest for wet type cooling towers and the lowest for dry type cooling towers. As the demand for water approaches available supply more closely, the cost differential incurred with supplemental types of cooling may be more than offset by the relative worth of the water supply conserved.

6. FLOOD DAMAGE PREVENTION

a. Flood History. Most of the floods in the Grand River basin occur in the late winter and spring months of February through May, and result from rain falling on frozen snow-covered or saturated ground. The floods are frequently accompanied by warming temperatures which melt channel ice. The ice breaks into large sheets and piles up in jams at bridges, thus further restricting the channel, raising flood stages upstream, and endangering the bridges.

Maximum unit discharges for the Grand River range from 11 to 20 cubic feet per second per square mile of drainage area. These rates are higher than peak rates for adjacent drainage areas of comparable size in southern Michigan. Floods are also experienced during June and July, resulting from very intense rainfalls. The limited aerial coverage of the intense rainfalls and the increased channel capacities of the downstream channels prevent widespread flood conditions from occurring. The major flood of record on the Grand River occurred in March 1904. Maximum discharges of 54,000 cubic feet per second at Grand Rapids and 24,500 cubic feet per second at Lansing were recorded. Other major floods of record of slightly less magnitude were experienced along the main stem of the river in March 1948, April 1947, March 1918, March 1908, and June 1905. In addition, water surface elevations above flood stages along the main stem were reached twice in 1949 and three times in 1950. These floods resulted from separate snow melts and high intensity rainfalls.

b. Past Developments. Following the March 1904 flood, the city of Grand Rapids expended approximately $1,000,000 for the construction of flood retaining walls and levees, with accompanying interior drainage along the banks of the Grand River within the city limits. These walls were designed with a two-foot freeboard allowance over the stages reached during the 1904 flood. Their effectiveness is evidenced by the fact that flooding damage since their construction has been confined to the southwestern section of the city of Grand Rapids which is not protected by the walls. However, the 1948 flood crested within two feet of the top of these walls. The downtown area of Grand Rapids extends along the left bank of the river immediately adjacent to this flood wall. Small service businesses, large and small industries,

and residential areas are located on the right bank of the river. The streets on both sides of the river in this section are several feet below the top of the flood wall. Because of channel silting and encroachment of the walls into the natural flood plain, a flood of the 1904 magnitude would probably overtop the flood walls.

The city of Jackson modified the Grand River channel by encasing the river in a concrete conduit placed on the existing riverbed through the central business district and by widening and straightening the river channel from Jackson Road to Berry Road, about eight miles north of Jackson. Most of the concrete conduit is exposed, except for a small section buried under buildings along both sides of Michigan Avenue. No significant flood damage has occurred since this improvement.

Lowhead power dams have been constructed and maintained on the Grand River and some of its tributaries, but they are not designed to provide flood damage reduction.

The Muskrat Creek Watershed, located in Clinton County, includes 4.6 miles of multiple-purpose (flood prevention and drainage) channel improvement. The Catlin-Waters Watershed, also located in Clinton County, includes 4.3 miles of multiple-purpose (flood prevention and drainage) channel

c. Needs. Needs are measured by the estimated annual flood damage to residential, commercial, and industrial properties in the Grand River basin. This study shows that flood damages to agricultural lands located along the main stream between the urban damage centers do occur but are not significant.

Needs are based on existing structures. It was assumed, for purposes of this study, that wise planning at all levels of government will prevent the construction of new structures in the flood plain or require floodproofing of existing structures.

Therefore, future flood damage in the flood plains was not projected on past trends because all available indicators show that construction will follow a different pattern from the past. However, it is fully recognized that damage potential exists and could result in significantly large dollar amounts if preventive measures are not taken.

Prevention or controlling of flooding is needed on the 635,000 acres in the Basin now vulnerable to floodwater damages or having wetness problems.

Within the upstream watersheds and tributaries, flood preventative measures are needed on 90,000 acres of flood plain lands.

Floodwater retarding structures and/or multiple-purpose channels (flood prevention and drainage) are required on sites of pronounced flood danger to alleviate the frequent flow and excessive runoff. Non-structural conservation measures for watershed protection are needed on 1.2 million acres within the Basin by 1980. These agronomic, grassland, and and woodland practices are also needed in conjunction with the structural measures, above and below the structure sites, and in areas of less pronounced flood danger (no structural site planned) to control the rate and amount of soil loss and water flow.

d. Flood Damage Centers. The study revealed ten flood damage centers.

(1) Ada. The flood problem at Ada results from high Thornapple River flows. Flood damages have been small, due to the small size of the community and the limited development of its flood plain. Average annual damage is $4,000.

(2) East Lansing. Floods at East Lansing result from excessive flows in the Red Cedar River in conjunction with high stages on the Grand River. Flood protection is required for substantial residential, educational, and retail developments. Average annual flood damage is $343,000.

(3) Eaton Rapids. Floods at Eaton Rapids result from high flows in Spring Brook coincident with high flows in the Grand River. The outlet capacity of Spring Brook is seriously impaired by high Grand River stages which cause Spring Brook flows to overflow the banks and drain naturally overland through the city of Eaton Rapids to the Grand River.

(4) Grand Rapids. Major flood damages would occur at Grand Rapids if Grand River stages were to exceed the flood wall built to protect the city after the record 1904 flood. The wall has never been overtopped, but the 1947 and 1948 floods came within two feet of overtopping it. The average annual damage is $429,000.

(5) Grandville. Flood damages at Grandville result from inadequate channel capacities in the Grand River adjacent to low-lying residential, commercial, and industrial areas. Average annual damage is $124,000.

(6) Ionia. Flood damages at Ionia result from inadequate channel capacities of the Grand River. When the limited area of the channel is exceeded, the waters spread over a broad flood plain. Damages are mostly restricted to farm lands and the Ionia County Fairgrounds. Average annual damage is $51,000.

(7) Lansing. Floods at Lansing result from high stages in the Grand River and in the Red Cedar River. The flood problem is generally limited to residential developments.

(8) Lowell. Lowell has a flood problem when high Flat River flows coincide with high Grand River flows. The high Grand River stages seriously impair the outlet capabilities of the Flat River, which in turn backs up and flows naturally overland through the downtown and residential areas of the city. Average annual damage at Lowell is $57,000.

(9) Plainfield Township. Flood problems in this area result from inadequate Grand River channel capacities due to intense residential use of the flood plain. Ice jams behind pilings and bridge piers intensify the problems. Average annual damage is $55,000.

(10) Lyons. The flood damages at Lyons resulted from flooding of low-lying lands due to backwater from a dam. No significant flood damage has occurred at Lyons since the dam was washed out in 1947.

e. Minor Flood Damage. Minor flood problems exist at Dimondale, Grand Ledge, Mason, Portland, and Saranac.

7. RECREATION

a. Demand. Land for recreation should be close to surface waters. Recreation areas adjacent to usable water have greater appeal to the recreationist than land devoid of water. Even activities not directly related to water--hiking and sightseeing--provide greater satisfaction when close to water. See Table II-13 for projections of demand for the Basin including land for parking. See Appendix J for demand by subareas. Table II-14 summarizes total annual occasions and recreation days by subarea in the Basin. It includes projections of demand for the five basic activities: swimming, boating, water skiing, camping, and picnicking; and the secondary activities: sighteeing, hiking, and nature walks.

Table II-13

Basin Summary of Demand Requirements

Activity	Year	Visitor Occasions Annual (1,000's)	Visitor Occasions Summer (1,000's)	Design Load Visits (1,000's)	Developed Acreage Requirements Land Activities	Developed Acreage Requirements Land Parking	Developed Acreage Requirements Water (1,000's)
Swimming	1960	3,338	2,895	42.0	98	120	
	1980	7,277	6,309	90.3	207	260	
	2000	13,204	11,447	161.1	377	469	
	2020	20,558	17,904	256.2	589	732	
Boating	1960	1,827	1,198	13.7		137	27.4
	1980	4,063	2,672	30.6		306	61.2
	2000	7,527	4,957	56.7		567	113.4
	2020	11,692	7,699	88.0		880	176.0
Water-Skiing	1960	202	159	.8		8	6.4
	1980	566	447	2.1		21	16.8
	2000	1,159	894	4.3		43	34.4
	2020	1,882	1,464	7.0		70	56.0
Camping	1960	614	379	10.8	273		
	1980	1,789	1,092	31.1	778		
	2000	3,910	2,392	68.6	1,710		
	2020	6,630	4,088	116.8	2,919		
Picnicking	1960	3,421	2,193	31.4	629	89	
	1980	6,295	4,049	57.8	1,159	166	
	2000	10,419	6,702	95.9	1,919	275	
	2020	15,779	10,123	144.3	2,891	413	
Secondary Activities	1960	8,837	3,305			55	
	1980	20,230	7,887			116	
	2000	38,049	14,802			220	
	2020	61,430	24,001			348	
Summary of all Activities	1960	18,239	10,129	98.7	1,000	411	33.8
	1980	40,220	22,456	211.9	2,144	871	78.0
	2000	74,272	41,195	389.6	4,006	1,574	147.8
	2020	117,971	65,279	612.6	6,398	2,443	232.0

Table II-14

Summary of Annual Occasions and Recreation Days

For all Activities

By Subarea and Year

Subarea		1960 (1,000's)	1980 (1,000's)	2000 (1,000's)	2020 (1,000's)
Jackson	A.O.*	1,927	4,250	7,851	12,470
	R.D.*	771	1,700	3,140	4,988
Lansing	A.O.	4,464	9,840	18,176	28,880
	R.D.	1,786	3,936	7,270	11,552
West Central	A.O.	4,869	10,737	19,822	32,491
	R.D.	1,948	4,295	7,929	12,996
Grand Rapids	A.O.	3,661	8,080	14,904	23,679
	R.D.	1,464	3,232	5,962	9,472
Northeast	A.O.	3,318	7,318	13,515	21,451
	R.D.	1,327	2,927	5,406	8,580
Total	A.O.	18,236	40,219	74,268	118,970
	R.D.	7,296	16,090	29,707	47,588

*A.O. - Annual Occasions

*R.D. - Recreation Days

b. Supply. The supply inventory is an analysis of public water oriented resource areas in the Grand River basin. The inventory includes Federal, State, county, and certain municipally administered areas. Those municipal recreation areas containing recreation facilities for one or more of the five major activities considered in this study were included in the supply inventory. Only those oriented primarily toward swimming pools and playgrounds were omitted from the inventory.

Camping facilities on private recreation areas were included in the inventory of supply. Lack of available data on privately operated facilities for other activities precluded an analysis of them.

Private recreation enterprises frequently serve as a holding unit for overflow from public areas and commonly do not provide a rounded recreation experience.

(1) Existing Supply. The existing supply was inventoried and evaluated on the basis of present development and current unused capacity. The inventory also includes programmed and potential areas with consideration given to type, quantity, and quality of land and water resources now available or suitable for future development.

Actual supply, or potential capacity, is measured in terms of developed acres for each activity and not on visitation estimates. That is, supply figures were derived in acres which could be converted to recreation days with the application of the Bureau of Outdoor Recreation design load standards. This allows the resource base carrying capacity to be interjected in the evaluation of existing sites and provides development guidelines necessary for the provision of a quality experience. See Figures II-1, II-2, and II-3 for location of existing recreation areas. A list of their names is given in Table II-15

Some of the existing State and county parks have relatively light development in relation to total land area available. In some instances, it may be the plan of the administrative governmental entity to retain certain unusual areas as outstanding natural areas with limited development. However, other areas can be developed more fully without crowding to provide additional facilities, especially for picnicking and camping, without the purchase of additional lands.

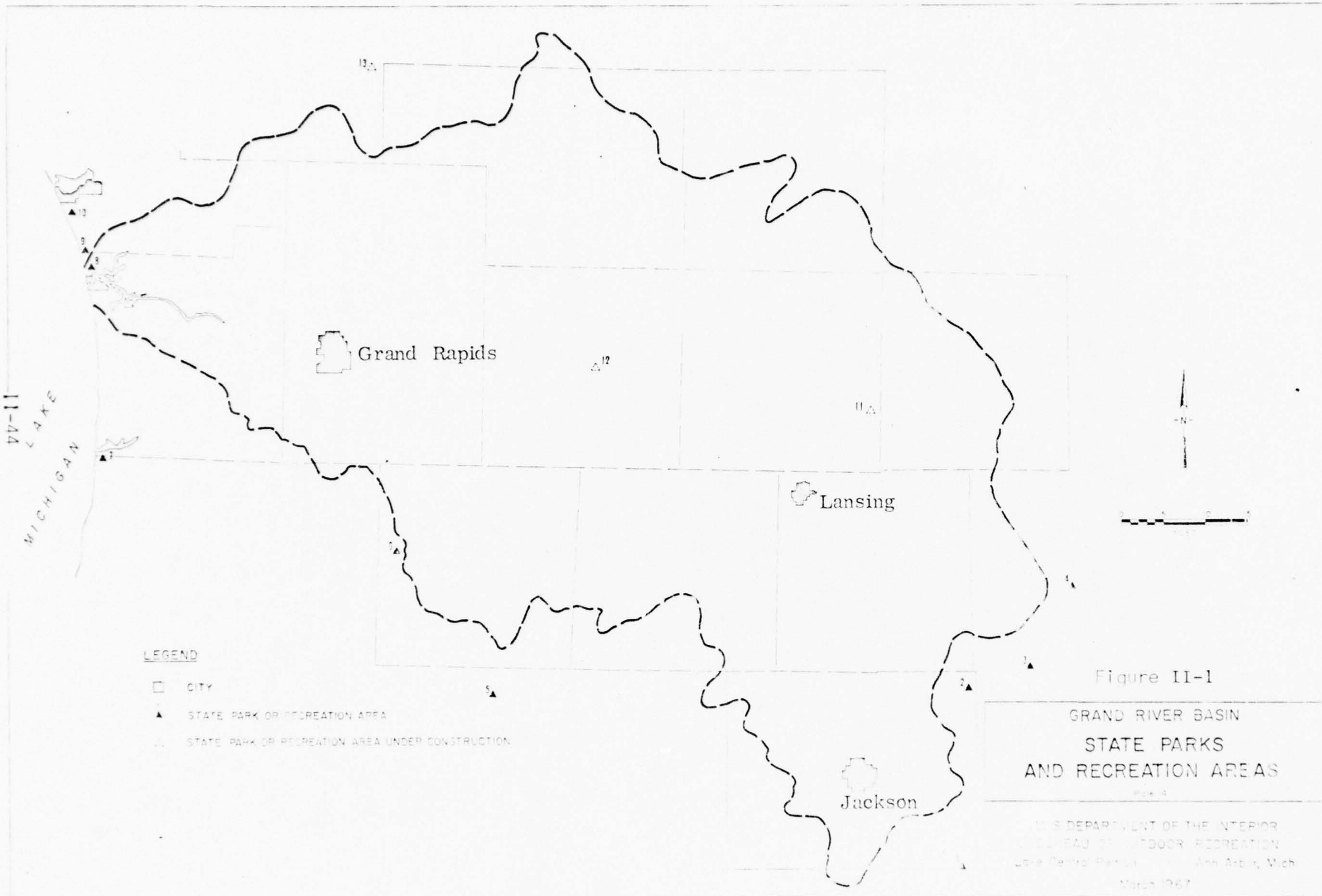

Grand Rapids
Lansing
Jackson
LAKE
MICHIGAN
LEGEND
CITY
STATE PARK OR RECREATION AREA
STATE PARK OR RECREATION AREA UNDER CONSTRUCTION
N
GRAND RIVER BASIN
STATE PARKS
AND RECREATION AREAS
U.S. DEPARTMENT OF THE INTERIOR
Ann Arbor, Mich
March 1967

Figure II-1

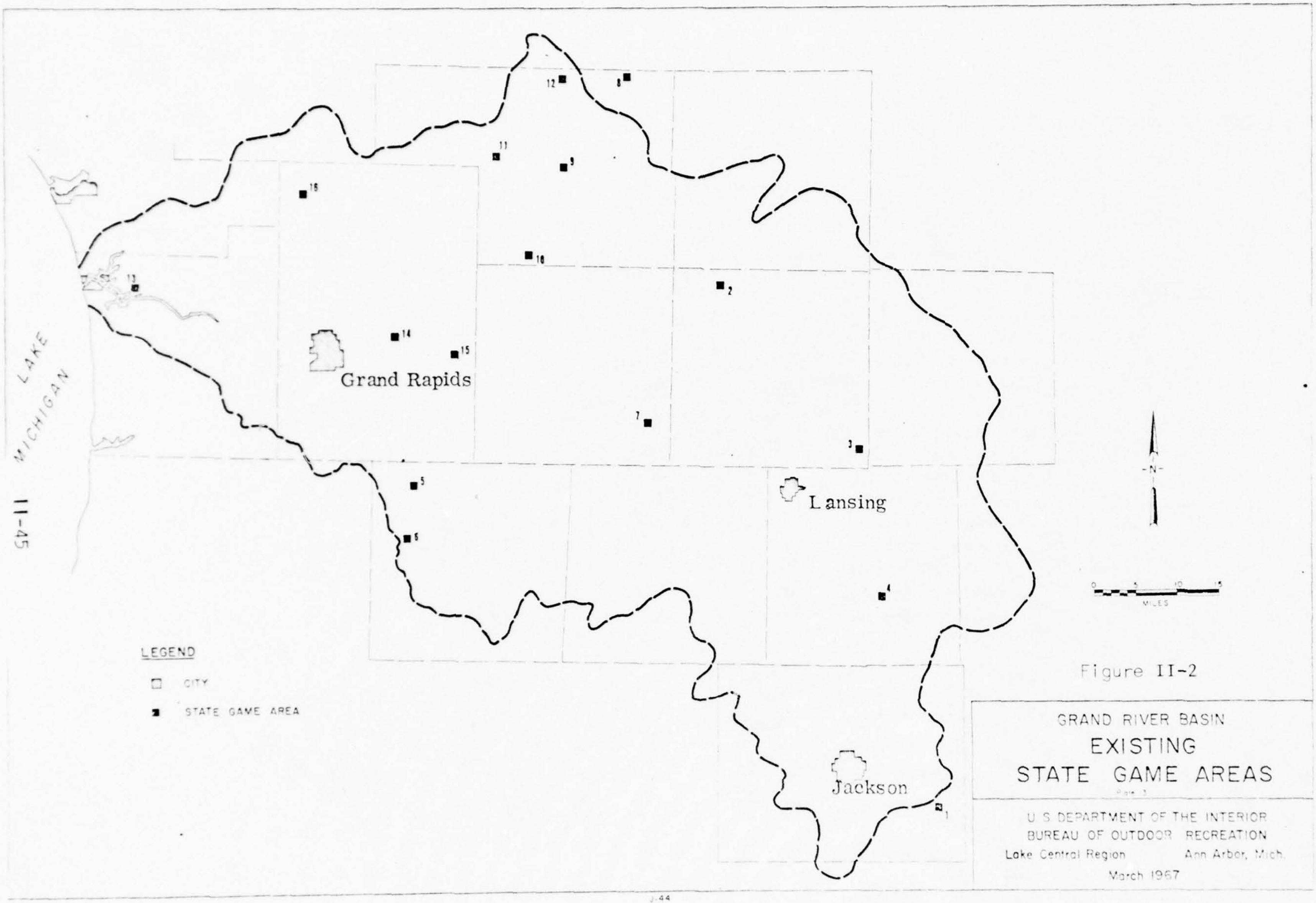
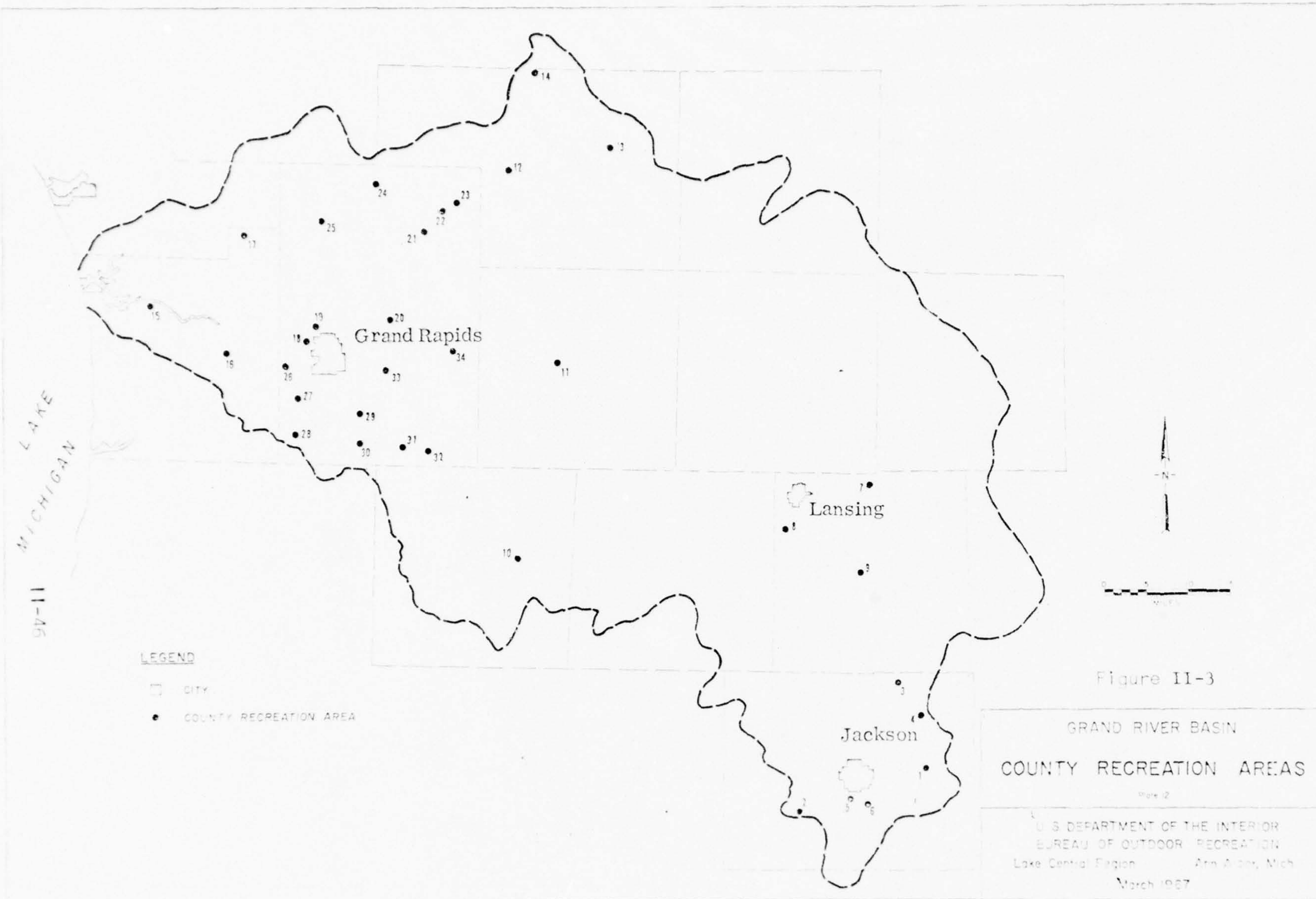


Figure II-2

GRAND RIVER BASIN
EXISTING
STATE GAME AREAS

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
Lake Central Region Ann Arbor, Mich.
March 1967

J-44



Grand Rapids
Lansing
Jackson
LAKE MICHIGAN
N
LEGEND
CITY
COUNTY RECREATION AREA
GRAND RIVER BASIN
COUNTY RECREATION AREAS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION
Lake Central Region
March 1967

Figure II-3

Table II-15

Names of Existing Public Recreation Areas In Or Near the Grand River Basin

State Parks and Recreation Areas

1. Walter J. Hayes State Park
2. Waterloo Recreation Area
3. Pinckney Recreation Area
4. Brighton Recreation Area
5. Fort Custer Recreation Area
6. Yankee Springs Recreation Area
7. Holland State Park
8. Grand Haven State Park
9. J. P. Hoffmaster State Park
10. Muskegon State Park
11. Sleepy Hollow State Park
12. Ionia Recreation Area
13. Newaygo State Park

State Game Areas

1. Sharonville
2. Maple River
3. Rose Lake Experiment Station
4. Dansville
5. Middleville
6. Barry County
7. Portland
8. Vestburg
9. Stanton
10. Flat River
11. Langston
12. Edmond
13. Grand Haven
14. Cannonburg
15. Lowell
16. Rogue River

County Park Areas

1. Grass Lake Park
2. Lime Lake Park
3. Pleasant Lake Park
4. Portage Lake Park
5. Sparks Park
6. Vandercook Lake Park
7. Lake Lansing
8. Grand River Park
9. Rayner Park
10. Charlton Memorial Park
11. Bertha Brock County Park
12. Flat Rock County Park
13. Krum Park
14. Townline Lake Park
15. Riverside Park
16. Hager Park
17. Grose Park
18. Dwight Lydell Park
19. Plainfield Park
20. Warren R. Townsend County Park
21. Lake County Park
22. White Pine County Park
23. Spencer Park
24. Gordon County Park
25. Longlake County Park
26. Henry A. Johnson Park
27. Linus C. Palmer Park
28. Douglas Walker Park
29. Paris Park
30. Dutton Shadyside Park
31. Caledonia Lakeside Park
32. Coldwater River Park
33. Chief Hazy Cloud Park
34. Fallsburg Park
35. Vineyard Lake Park*
36. Swains Lake Park*

* Not shown in Figure II-3

Where surface water is available, a potential for additional swimming facilities also may be developed. Where it is practical and feasible to do so, all existing park sites should be developed to their maximum potential in accordance with the proposed type of development planned for them and without sacrifice of the potential for a quality experience.

The supply of water surface was determined from lakes larger than 20 acres and from the Grand River surface. Those lakes with developed public access were classified as existing supply. Fifty percent of the surface area of those lakes provide opportunities to the owner and his friends. The remaining 50 percent was considered as potential supply. The water surface of the Grand River from Lake Michigan to Lansing was included as existing supply, although access to it is rather limited. Tributary streams were not included since they provide only very limited opportunity for boating and practically no opportunity for water skiing. They do provide opportunities for fishing. See Table II-16 for existing supply.

Water quality was considered, but it was not permitted to affect the evaluation of supply. Sufficient data is not available to evaluate the quality of water, lake by lake. However, with the intensive residential development on the shores of many lakes, and the lack of central sewage systems around most of them, it is reasonably safe to assume that the quality of the water in many of these lakes has been degraded to some extent by pollutants. It was disclosed recently that even the main body of Lake Michigan waters is being degraded more rapidly than previously surmised.

(2) Private Supply. In 1965 the Soil Conservation Service cooperated with the National Association of Soil and Water Conservation

Table II-16

Public Recreation Supply Available in Subareas and Basin - 1965

Activity	Land Acres	Water Surface Acres
Jackson Subarea		
Swimming	12	
Boating and Water Skiing	9	7,400
Camping	53	
Picnicking	88	
Parking	32	
Lansing Subarea		
Swimming	0	0
Boating and Water Skiing	3	1,500
Camping	9	
Picnicking	70	
Parking	7	
West Central Subarea		
Swimming	27	
Boating and Water Skiing	25	18,000
Camping	31	
Picnicking	88	
Parking	70	
Grand Rapids Subarea		
Swimming	28	
Boating and Water Skiing	5	11,100
Camping	22	
Picnicking	209	
Parking	35	
Northeast Subarea		
Swimming	0	
Boating and Water Skiing	1	
Camping	0	1,000
Picnicking	5	
Parking	1	

Table II-16 (Continued)

Public Recreation Supply Available in Subareas and Basin - 1965

Activity	Land Acres	Water Surface Acres
Summary		
Swimming	67	
Boating and Water Skiing	43	39,000
Camping	115	
Picnicking	460	
Parking	145	

Districts in an inventory of private outdoor recreation enterprises. This inventory developed detailed data on a county basis for twelve broad enterprise types.

According to Woodall's Trailering Parks and Campgrounds, there are 29 private campgrounds providing a total of 680 camping spaces in the 11 counties in this study. They range in size from 2 to more than 100 spaces each and provide a variable range of services, ranging from a bare minimum to opportunities for swimming, boating, fishing, and other outdoor games. Of the 29 sites, 9 provide opportunities for swimming, 8 for boating, [illegible] for picnicking, and 12 for other outdoor activities. See Table II-17 for a breakdown by subarea.

Based on the design load used earlier in this study, the 680 camping sites are equivalent to 68 acres of developed land. This equivalent was included in the existing supply.

(3) Programmed Supply. Programmed supply was obtained from the Michigan Statewide Plan, while potential water sites were identified by the Corps of Engineers, Soil Conservation Service, and Michigan Water Resources Commission. Additional information concerning potential recreation areas was gathered during Basin reconnaissance trips and personal contact with area and county planning commissions.

Determination of the 1980 unsatisfied demand required identification of the capabilities of future outdoor recreation programs as described in county and State plans. To qualify as a programmed area, an individual project must be planned for development with a site plan and activity breakdown. Those projects which could be listed only as hopeful acquisitions were not included in programmed supply in the study.

Plans are being developed by the Soil Conservation Service for flood prevention measures on the upper part of the Maple River under Public Law 566. Two structures are being proposed for flood prevention and recreational purposes. The Sleepy Hollow site on the Little Maple River is already under development by the State of Michigan. The planned facilities for this site are included in the programmed supply available. The other proposed structure located on Bear Creek will provide a

Table II-17

Summary of Camping and Related Recreational Facilities Provided by the Private Sector

Subarea	Number of Areas	Number of Camping Spaces	Equivalent Acres of Developed Land	Number of areas providing opportunities for			
				Swimming	Boating	Picnicking	Other
Jackson	8	253	25	2	2	5	3
Lansing	4	26	3	1	-	1	1
West Central	7	113	11	4	4	4	4
Grand Rapids	10	288	29	2	2	3	4
Northeast	-	-	-	-	-	-	-
Total	29	680	68	9	8	13	12

recreational pool of 235 acres. When this site is developed, it also will provide a significant quantity of additional facilities in an area of substantial demand, but with limited opportunity. This site was not included in programmed supply.

The State is also developing a recreation area near Ionia which was included in programmed supply. Newaygo State Park, now being planned, will provide recreational opportunity also, but it was not included in programmed supply because it lies outside of the study area.

Recreational facilities programmed for development were not enumerated by site. Each project was evaluated for its contribution to the required activity facility needs across the Basin. As is the case with supply and demand, all computations are expressed in terms of acres of land and water which may be converted to visitor days when required. A summary of programmed development is set forth in Table II-18.

c. Needs. Need is defined as the difference between the existing recreation supply and the total demand. The 1960 need was derived by subtracting yhe existing 1965 supply from the total 1960 demand. Projected activity needs were determined by subtracting the 1965 supply and the programmed supply from projected demands.

The needs for sightseeing, nature walks, and hiking were computed by applying a percentage figure for each of these activities to the sum of the annual visits for the five activities projected in detail.

The percentages used for sightseeing, nature walks, and hiking were 60 percent, 18 percent, and 4 percent, respectively. These figures were obtained from the per capita participation rates for 1960 in the Outdoor Recreation Resource Review Commission Reports.

The study assumes that if the water-oriented needs of the five previously defined activities are provided in a quality setting sufficient land will be available for the associated less intensive activities, such as hiking and sightseeing. Table II-19 is a summary of projections of needs.

The table for needs in 1980 shows the Jackson Subarea with substantial surpluses in camping and the Grand Rapids Subarea with surpluses in picnicking.

Table II-18

Acreage Programmed for Public Recreational Development by 1980

Activity	Jackson	Lansing	West Central	Grand Rapids	North-east	Basin Total
Land						
Swimming	0	6	7	9	0	22
Boating and Water Skiing	2	5	3	7	0	17
Camping	21	26	45	54	0	146
Picnicking	31	61	50	68	2	212
Parking	0	18	20	25		63
Water Surface	0	410	85	-	-	495

Table II-19

Basin Summary of Projected Recreation Needs

Activity	Year	Demand in Acres: Developed Land	Demand in Acres: Water Surface (1,000's)	Supply in Acres: Developed Land A*	Supply in Acres: Developed Land B**	Supply in Acres: Water Surface (1,000's) A*	Supply in Acres: Water Surface (1,000's) B**	Need in Acres: Developed Land	Need in Acres: Water Surface
Swimming	1960	98		67				31 ***	
	1980	207			22			118	
	2000	377						288	
	2020	589						500	
Boating	1960	145	33.8	43		39.0		102	
and	1980	327	78.0		17		.5	267	38.5
Water	2000	610	147.8					550	108.3
Skiing	2020	950	232.0					890	192.5
Camping	1960	273		183				90	
	1980	778			146			450	
	2000	1,710						1,381	
	2020	2,919						2,590	
Picnicking	1960	629		460				169	
	1980	1,159			212			487	
	2000	1,919						1,247	
	2020	2,891						2,218	
Parking	1960	264		145				119 ****	
	1980	544			63			336	
	2000	964						756	
	2020	1,493						1,286	
Summary of above Activities	1960	1,409	33.8	898				511*****	
	1980	3,015	78.0		460			1,658	38.5
	2000	5,580	147.8					4,222	108.3
	2020	8,842	232.0					7,484	192.5

* Existing developed land; ** Land programmed for development before 1980.

*** The area of water surface projected to satisfy needs for boating and water skiing will provide the small amount of water surface needed for swimming.

**** Land for parking includes that needed for all parking except boating, water skiing and camping which is included in land needed for the activity.

***** Total needs cannot be accurately obtained by subtracting total supply from total demand because surpluses of facilities in one activity cannot be used to offset a need in another.

****** Indicates surpluses.

The projections of demand and needs do not reflect an accurate picture of the intensity of pressures exerted on the Jackson Subarea. The demand from the Detroit Standard Metropolitan Statistical Area for recreational facilities is much greater, proportionately, in this area of rolling relief than it is in the more level areas of the lake plain within the Detroit service area. Similar conditions exist for other Standard Metropolitan Statistical Areas where substantial portions of their respective service areas lie upon relatively flat lake plain relief. However, no attempt was made to adjust effective population and demand figures for this factor because of its nebulous nature and the difficulty in developing a reliable tool to make reasonably accurate corrections. Therefore, surpluses in the Jackson Subarea could easily be more of a paper nature than an actuality.

Surpluses in the Grand Rapids Subarea result from the presence of extensive recreational facilities in or near the area and proposed development of substantial additional facilities over the next few years.

The presence of surpluses in certain subareas affects the needs picture for the Basin as a whole. When needs are computed for the Basin as a whole, surpluses in one subarea reduce needs in other subareas. Therefore, the sum of the needs for the five subareas may be greater than the stated needs for the Basin as a whole.

There may be a surplus of recreational facilities for certain activities in some subareas when a major reservoir is constructed. However, when reservoirs are built it will be necessary to construct recreational facilities on adjacent lands even if the construction creates a surplus or increases an existing surplus. Such construction will permit the development of a complete recreational facility adjacent to large bodies of water. In most cases, these surpluses will be of a temporary nature and will be absorbed by an increasing demand within a few years. Most of these surpluese will probably be evident at relatively small areas that do not provide an opportunity for a variety of recreational experiences.

The trend toward urbanization has been in progress for many years.

This trend is creating large population centers, and provision of sufficient outdoor recreation facilities in close proximity to the people will be difficult, if not impossible.

8. FISH AND WILDLIFE

Traditionally, fish and wildlife resource planning has developed on a three-phased approach; (1) an inventory of physical and biological resources; (2) an estimation of future demands on these resources; and (3) a plan of development to satisfy the demand. The rationale of the approach and methods of providing the needed information have varied from study to study, but these elements are usually present.

In this study the "user-day" was chosen as the index of comparative need. The plan simply weighs user-days provided by the existing conditions supplemented by acquisition or construction of proposed fish and wildlife facilities, against the number of user-days required. These plans are based on several premises, a major one being, that if the necessary lands and waters are acquired and made available to the public, the resource manager and researcher will in turn provide the stock of fish and game required to sustain the increased demands for hunting and fishing.

A comparison of projected supplies and gross demands permits an evaluation of further net hunting and sport fishing demands.

a. Gross Demands. To arrive at projected gross demand figures for the target years 1980, 2000, and 2020, the projected 1980 hunter and sport fisherman participation rates for each subarea were assessed against each subarea's projected 1980, 2000, and 2020 participants. Gross subarea and Basin demands, expressed as angler and hunter days, are shown on Tables II-20 and II-21, respectively.

Gross demand for fishing generated in the Basin in expected to increase from 1,517,000 angler days in 1960 to 2,000,300 in 1980 (32%); 2,647,400 in 2000 (75%); by 2020, demand is estimated to be 3,341,400 angler days or a 120% increase when compared to 1960 angler demand.

Gross hunting demands were estimated to be 1,459,100 hunter-days use within the Basin in 1960. Demand is expected to decrease slightly to

1,400,900 hunter days by 1980 (-4%); then increase to 1,790,300 by 2000 (23%); and ultimately to 2,269,700 hunter-days use by 2020, an increase of 56% when compared with 1960 gross hunter demand. The decreased overall Basin demand predicted from 1960 to 1980 is a result of a projected decrease in number of days of participation per hunter, even though the actual number of hunting participants is expected to increase in the interim 1960 to 1980. Indications are that decreasing participation may level off by 1980. Thus, in conjunction with continued increasing numbers of hunters will result in increased gross demands by the year 2000 and 2020. Strategically located hunting opportunity developments, in place by 1980, should generate demand by increasing participation rates, while also satisfying existing unfulfilled hunter needs.

Table II-20

A Summary of Projection Data Relative to Future Fishing Demand in the Grand River Basin, 1960 - 2020

(All Data Expressed in 1000's)

	Grand Rapids Subarea	West Central Subarea	Lansing Subarea	Northeast Fringe Subarea	Jackson Subarea	Basin Total
Population						
1960	461.9	110.6	299.0	90.4	132.0	1093.9
1980	635.6	142.8	434.8	115.6	177.0	1505.8
2000	900.1	184.0	626.6	154.2	250.7	2115.6
2020	1242.6	233.3	867.6	198.8	338.7	2881.0
Total Anglers (From Basin)						
1960	84.1	36.0	43.2	15.2	24.3	202.8
1980	124.1	47.2	73.9	22.4	37.2	304.8
2000	162.7	60.6	101.1	29.4	50.8	404.6
2020	197.7	75.8	132.6	37.2	65.6	508.9
Total Anglers (Using Basin)						
1960	33.4	37.4	24.9	10.5	40.7	146.9
1980	49.3	49.1	42.6	15.4	62.3	218.7
2000	64.6	63.0	58.4	20.2	85.1	291.3
2020	78.5	78.8	76.5	25.6	109.8	369.2
Gross Angler-Day Demand (Using Basin)						
1960	401.4	610.6	116.6	80.6	307.8	1517.0
1980	486.3	646.9	309.1	101.6	456.4	2000.3
2000	637.7	829.8	423.1	133.3	623.5	2647.4
2020	774.6	1037.9	554.8	169.1	805.0	3341.4
Net Angler-Day Demand (Using Basin)						
1980	84.9	36.3	192.5	21.0	148.6	483.3
2000	236.3	219.2	306.5	52.7	315.7	1130.4
2020	373.3	427.3	438.2	88.5	497.2	1824.5

Table II-21

Summary of Projection Data Relative to Future Hunting Demand in the Grand River Basin, 1960 - 2020

(All Data Expressed in 1000's)

	Grand Rapids Subarea	West Central Subarea	Lansing Subarea	Northeast Fringe Subarea	Jackson Subarea	Basin Total
Population						
1960	461.9	110.6	299.0	90.4	132.0	1093.9
1980	635.6	142.8	434.8	115.6	177.0	1505.8
2000	900.1	184.0	626.6	154.2	250.7	2115.6
2020	1242.6	233.3	867.6	198.8	338.7	2881.0
Total Hunters (From Basin)						
1960	65.8	25.0	46.5	20.1	16.9	174.3
1980	96.5	30.6	68.7	24.9	24.1	244.8
2000	131.3	35.7	93.7	30.1	32.7	323.5
2020	178.3	41.6	124.5	36.4	42.1	422.9
Total Hunters (Using Basin)						
1960	45.0	34.5	37.8	16.3	13.1	146.7
1980	66.0	42.2	55.9	20.3	18.6	203.0
2000	89.8	49.2	76.3	24.5	25.3	265.1
2020	122.0	57.4	101.3	29.6	32.5	342.8
Gross Hunter-Day Demand (Using Basin)						
1960	281.9	413.4	366.2	242.5	155.1	1459.1
1980	258.2	407.5	348.2	238.7	148.3	1400.9
2000	351.2	475.1	475.1	288.2	200.7	1790.3
2020	476.9	554.0	631.4	348.7	258.7	2269.7
Net Hunter-Day Demand (Using Basin)						
1980	None	None	None	None	None	None
2000	117.7	69.8	145.0	52.8	58.7	444.0
2020	281.1	154.1	327.9	118.3	126.4	1007.8

b. Supply. After determining gross demand within the Basin, it was necessary to estimate future changes in opportunity (supply), represented by acres and typs of hunting and fishing habitat. The 1960 indices of pressure on given units of habitat (Tables II-22 and II-23) can be considered near their capabilities, at least within the framework of known or foreseeable determinants. Indications are that pressure on a given area of habitat remains relatively stable, over a period of years, if the resources sustained on the habitat remain stable. Therefore, that portion of the habitat base present in near future years should support hunting and fishing at a rate consistent with present use.

The angler is normally provided with ever increasing acreages of ponded water to supply fishing needs through reservoir construction programs. Impoundments, however, are usually gained at the expense of stream fishing habitat. To compensate for losses of stream environment it will be necessary to continually attempt to improve residual stream fisheries through better fishing management methods or through more effective pollution abatement programs, while simultaneously extending access provision programs. The initial success of the salmon introduction program symbolizes a bright future for many Michigan rivers and streams, including those within the Grand River basin, and represents a new effort in increasing the fisheries base of the State.

The hunter seldom realizes an increasing habitat base. More often, huntable habitat is consumed by urban sprawl, highways, changing attitudes of landowners towards the hunter, and other habitat-depriving measures of a burgeoning population. Information on projected land use changes, provided by the Economic Research Service, United States Department of Agriculture, East Lansing, Michigan, was taken into consideration in all hunting projections; especially as they indicated reductions or shifts in huntable land bases.

Table II-22 A Summary of Fishery Use and Resource Information - Grand River Basin, 1960

County by Subarea	1 Quality Stream Miles	Other Stream Miles	3 Ponded Water Acres 1000's	4 Acres Habitat Per Capita	5 Resident Licensed Anglers 1000's	6 Anglers From Basin 1000's	7 Anglers Using Basin 1000's	8 Use/ Stream Mile	9 Use/ Ponded Water Acre
Grand Rapids									
Ottawa	12	307	6.3	.07	12.9	20.2		59	19
Kent	180	772	8.0	.02	45.2	63.8		77	22
Subarea	192	1079	14.8	.03	58.1	84.0	33.4	72	21
West Central Belt									
Montcalm	87	477	7.2	.21	9.0	13.2		73	21
Ionia	70	464	1.8	.05	7.0	10.7		70	19
Barry	70	272	11.5	.38	8.3	12.1		79	27
Subarea	227	1213	20.5	.20	24.3	36.0	37.4	73	25
Lansing									
Clinton	80	319	0.8	.03	4.3	6.1		78	19
Eaton	33	207	0.7	.02	7.3	10.6		71	23
Ingham	30	234	0.9	.01	18.7	26.6		68	23
Subarea	143	760	2.4	.01	30.3	43.3	24.9	73	22
Northeast Fringe									
Gratiot	25	241	1.4	.04	4.3	6.3		65	19
Shiawassee	20	307	0.9	.02	5.6	8.9		61	19
Subarea	45	548	2.3	.03	9.9	15.2	10.5	63	19
Jackson									
Jackson	60	324	9.8	.08	16.2	24.3	40.7	73	29
Basin Total	667	3924	49.8		138.8	202.8	146.9		
Basin Mean				.05				72	24

Table II-23 A Summary of Game Use and Resource Information - Grand River Basin, 1960

County By Subarea	1 Waterfowl Habitat Acres 1000's	2 Public Huntable Acres 1000's	3 Private Huntable Acres 1000's	4 Total Huntable Acres 1000's	5 Acres Habitat Per Capita	6 Resident Licensed Hunters 1000's	7 Hunters From Basin 1000's	8 Hunters Using Basin 1000's	9 Use Per Huntable Acre
Grand Rapids									
Ottawa	10.6	3.6	329.5	333.1	3.4	14.3	17.2		.33
Kent	13.3	21.3	451.7	473.0	1.3	40.5	48.6		.36
Subarea	23.9	24.9	781.2	806.1	1.8	54.8	65.8	45.0	.35
West Central Belt									
Montcalm	14.9	16.9	429.3	446.2	12.5	8.3	10.0		.36
Ionia	12.7	7.9	343.5	351.4	8.2	6.7	8.1		.34
Barry	15.4	22.6	311.6	334.2	10.5	5.8	6.9		.40
Subarea	43.0	47.4	1084.4	1131.8	10.2	20.8	25.0	34.5	.37
Lansing									
Clinton	14.8	22.3	327.7	350.0	9.2	6.3	7.6		.39
Eaton	13.7	1.0	341.7	342.7	6.9	8.5	10.2		.33
Ingham	15.2	11.6	307.3	318.9	1.5	23.9	28.7		.37
Subarea	43.7	34.9	976.7	1011.6	3.4	38.7	46.5	37.8	.36
Northeast Fringe									
Gratiot	15.7	14.3	336.7	351.0	9.5	7.5	9.0		.36
Shiawassee	14.5	7.9	318.2	326.1	6.1	9.2	11.1		.35
Subarea	30.2	22.2	654.9	677.1	7.5	16.7	20.1	16.3	.36
Jackson									
Jackson	23.2	19.3	386.3	405.6	3.1	14.1	16.9	13.1	.38
Basin Total	164.0	148.7	3883.5	4032.2		145.1	174.3	146.7	
Basin Mean					3.7				.36

Each resource oriented agency whose program could affect existing or create future Basin fish and wildlife habitat was contacted and requested to project or give estimates of their construction or management plans to the year 1980. Details of these programs are discussed in the following section of this report.

c. Net Demands. Near future (1980) net demands for hunting and sport fishing were determined by subtracting existing (1960) use from the projected 1980 gross demand. Consideration was also given to acres of hunting opportunity lost during the interim 1960-1980.

Hunting and sport fishing net demands for 2000 and 2020 were determined using the same method as used for the near-future (1980). Therefore, 2000 and 2020 net demands were a function of the gross demand changes in the interim years (1980-2000 and 2000-2020), the carryover net demands from the previous target year (if any), and in considering hunting needs, the effects of land use changes on opportunity and use.

The reservoir construction and other fishery development programs completed prior to 1965 and contemplated for the period 1965-1980 will affect angler interest and demand, as will the population increase expected prior to 1980. It is estimated that the 1980 net Basin sport fisheries demand will require an additional 483,300 angler-days of opportunity over that available in 1960 (Table II-20). Net demands are expected to increase 1,130,400 angler-days by 2000 and 1,824,500 by 2020, over those provided in 1960. Angler needs will not be evenly spaced over the Basin.

Projected changes in land use and availability indicate that 151,000 Basin acres will be lost from the existing hunting base by 1980; an additional 224,000 acres will be lost by 2000; and 282,000 acres will be altered unfavorably for hunting from 2000 to 2020.

The 1960 hunting base of 4,032,500 acres will thus decline to 3,881,500 acres in 1980; to 3,657,500 acres in 2000; and to 3,375,500 acres in 2020.

Although net demands for additional hunting opportunities are not projected for 1980, net demands will soon appear in the interim 1980 to 2000. By 2000, net hunter demands are expected to be 444,000 user-days,

which increases to 1,007,800 net hunter days demand by 2020 (Table II-21). Net hunting demands would be considerably greater if all the demand which originates within the Basin were expended on in-Basin facilities.

Plans presented in this report will provide guidance in meeting these further net fishing and hunting demands. The number of days-use provided by a particular project completed prior to 1980 would satisfy the demand projected for the 2000 to 2020 period. Where large net demands are not projected for a particular subarea by 1980, lands for future development could be acquired and held in escrow against post-1980 demands. This method would also hedge against escalation of land prices in future years.

9. WATER QUALITY

a. General. The problems of water quality control in the Grand River basin are complex. Solutions to these problems will of necessity involve a comprehensive program which includes construction of new sewerage facilities; and continuous and intensive monitoring of operating procedures, treatment plant efficiency, and water quality conditions to determine necessary additional construction and operation needs as they arise. In addition, some combination of advanced waste treatment and low-flow regulation may be required to attain the desired water quality below Jackson and Lansing. The following paragraphs present information on waste sources, projected waste loads, and water quality improvement measures which should be employed.

b. Waste Sources. The Grand River and the streams tributary to it receive an estimated organic waste load of 32,000 pounds of 5-day biochemical oxygen demand (BOD_5) per day. Approximately 15,000 pounds are from industries with separate discharges. The most significant waste loads in terms of water use impairment are discharged at Jackson and Lansing.

The following paragraphs summarize the major waste sources in the Basin.

Table II-24 Municipal Waste Inventory of Major Communities
Grand River Basin

Community	Receiving Stream	Miles Above Mouth of Grand River	Treat-ment	Population Connected	Population Equivalent Estimated Waste Untreated	Treated	%BOD_5 Reduction
Jackson	Grand River	216.4	Secondary	51,000	53,000	3,690	93
Jackson State Prison	Grand River	214.2	Secondary	6,500	11,400	1,600	86
East Lansing	Cedar River	160.0	Secondary	35,000	50,000	5,000	90
Lansing	Grand River	150.5	Secondary	130,000	170,000	17,000	90
Grand Ledge	Grand River	138.6	Primary	5,100	6,600	4,300	35
Saint Johns	Hayworth Creek	121.3	Secondary	5,600	7,300	1,415	81
Hastings	Thornapple River	102.8	Primary	6,350	8,250	5,350	35
Greenville	Flat River	98.1	Primary	7,400	9,600	6,250	35
Ionia	Grand River	89.2	Primary	6,600	8,600	5,600	35
Grand Rapids	Grand River	40.6	Secondary	220,000	285,000	28,500	90
Grandville	Grand River	34.3	Secondary	8,000	4,800	500	90
Wyoming	Grand River	-	Secondary	56,000	36,000	6,900	81
Grand Haven	Grand River	1.0	Primary	11,000	14,300	9,300	35

Table II-25

Industries with Separate Outfalls
by Type of Industry

Pulp and paper

Paper converting (tissue, corrugated boxes, cartons, laminating, and gummed paper)

Packing Corporation of America
Grandville

Packing Corporation of America
Grand Rapids

Fine paper

Rockford Paper Mills, Inc.
Rockford

Food processing

Canning, fruit and vegetable packing (canned fruit and vegetables, meat, etc., frozen fruit and vegetables, fresh vegetable preparation and packing)

National Fruit Products
Company, Inc.
Kent City

Withrow Pickle Company
Sand Lake

Aunt Jane's Foods
Division of the Borden Company
Edmore

Ore - Ida Foods, Inc.
Greenville

Duffy - Mott, Inc.
Bailey

Hudsonville Dairy
Hudsonville

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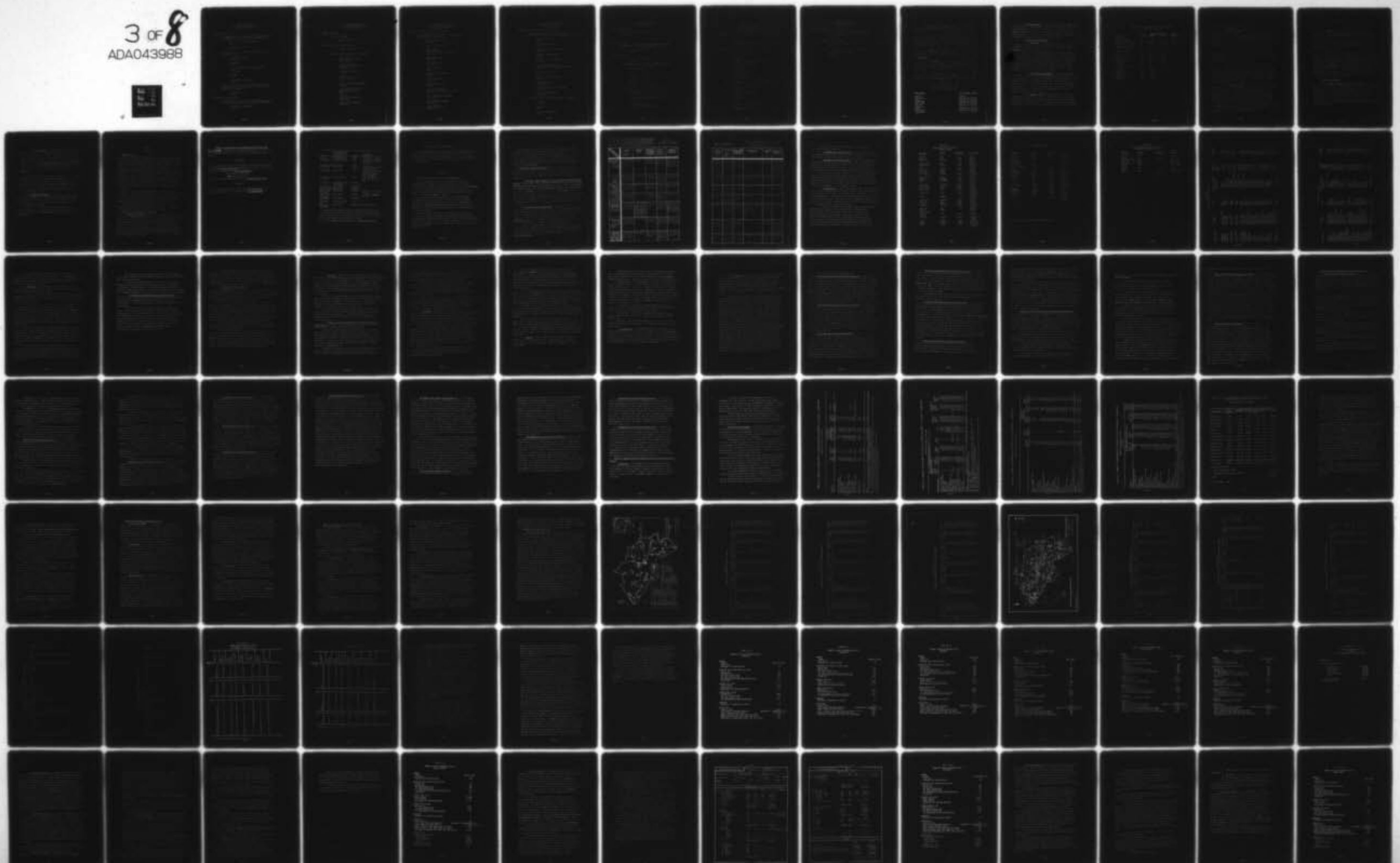


Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Food processing (Cont'd)

Milk processing (butter, fluid milk, condensed milk, dried milk, whey powder, milk chemicals, ice cream mix, etc.)

Michigan Milk Producers Association
Ovid

Carnation Milk Company
Sheridan

Meat packing and allied industries (meat, poultry, fish, animal and pet food)

Buggs Brother Lockers
St. Johns

Store-A-Way, Inc.
DeWitt

U. S. Department of Agriculture Research Center
East Lansing

Ada Beef
Ada

Allendale Packing Company
Allendale

Miscellaneous Foods (baking, soft drinks, vegetable oils, margarine, shortening, candy, sugar refining, specialty foods, potato pancakes)

Indian Summer, Inc.
Belding

Petroleum and petrochemicals

Oil refining and petrochemicals (fuels, lube oils, etc., solvents, aromatics, l. p. gases, chemical intermediates)

Crystal Refining Company
Crystal

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Chemical specialties

Soaps and detergents

Amway Corporation
Ada

Metal working, plating and finishing

Hancock Industries, Inc.
Elsie

Automotive (automobiles, parts, accessories)

Olds Division
General Motors Corporation
Delta Township

Olds Forge Division
General Motors Corporation
Lansing

John Beam Corporation
Lansing

Lyons Trim
Chrysler Corporation
Lyons

Hastings Manufacturing Company
Hastings

Diesel Equipment Division
General Motors Corporation
Wyoming

Plant No. 2
General Motors Corporation
Grand Rapids

Federal Mogul Corporation
Greenville

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Metal working, plating and finishing (Cont'd)

Plating and anodizing (chromium, nickel, copper, zinc, precious metals) - job plating

Federal Mogul Corporation
St. Johns

American Anodco Corporation
Ionia

Utilex Division
Hoover Ball and Bearing Company
Fowlerville

Keeler Brass Company
Middleville

Ace Plating Company
Grand Rapids

Attwood Corporation
Lowell

Grand Rapids Brass Company
Wyoming

Jervis Corporation
Grandville

Knape Industries, Inc.
Rockford

Nelson Metal Products
Division of Midland Ross Corporation
Grandville

A. S. P. Manufacturing Company
Grand Haven

Grand Haven Brass Company
Grand Haven

Leigh Products, Inc.
Coopervi lle

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Metal working, plating and finishing (Cont'd)

Forming, stamping and finishing (extrusions, wire, shapes, bonderizing, painting, tubes, pipes, forgings)

Ashley Corporation
Ashley

Clark Equipment Company
Jackson

Lefere Forge and Machine Company
Jackson

Pittsburgh Forging Company
Jackson

Hastings Aluminum Products, Inc.
Hastings

Extruded Metal Division
Detroit Gasket and Manufacturing Company
Belding

Universal Metal Products
Saranac

Reynolds Aluminum Corporation
Wyoming

Challenge Porcelain
Grand Haven

Grand Haven Stamped Products Company
Grand Haven

Oldburg Machine Company
Grand Haven

Miscellaneous metal industries (foundries, hardware, etc.)

E. W. Bliss
Hastings

Bissell, Inc.
Walker

Sparta Foundry Company
Sparta

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Tanning and rendering

Tanning (leather, skins, etc.)

Building products

Miscellaneous building materials (portland cement, lime, ready mix concrete, asphalt paving mix)

Workman Richardson
Jackson

Service industries

City of Lansing Asphalt Plant
Lansing

Transportation (trucking, railways, airlines, shipping)

Grand Trunk Western Railroad
Delta Township

Penn Central Railroad
Jackson

Chesapeake and Ohio Yards
Wyoming

Wolverine Finishes Corporation
Wyoming

Utilities (thermal and nuclear electric generation)

Lansing Board of Water and Light
Delta Township

Otto E. Eckert Moores Park Power Station
Lansing Board of Water and Light
Lansing

Ottawa Street Station
Lansing Board of Water and Light
Lansing

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Service industries - Utilities (thermal and nuclear electric generation)
(Cont'd)

Michigan Consolidated Gas Company
Six Lakes

Miscellaneous manufacturing

4 - D Corporation

T. M. C. Industries
Belding

Debruyn Products Company and Debruyn Texas
Products Company

National Water Lift Company
Cascade Township

Cascade Data
Cascade Township

Ranney Refrigeration Corporation
Greenville

Electrical and electronic (appliances, telephone equipment,
television tubes)

White Products Corporation
Middleville

White Consolidated Industries
Belding

Kelvinator, Inc.
Wyoming

Jet Electronics and Technology, Inc.
Grand Rapids

White Consolidated Industries
Greenville

Table II-25 (Cont'd)
Industries with Separate Outfalls
by Type of Industry

Miscellaneous manufacturing (Cont'd)

Paint and varnish (conventional paint, latex emulsions)

Industrial Painting
St. Johns

Rubber (tires, industrial)

Goodyear Tire and Rubber
Jackson

Glass and ceramics (bottles, pottery, insulators, etc.)

Owens-Illinois Glass Company
Charlotte

(1) Municipal. Approximately 540,000 people were served by 47 municipal sewage treatment facilities in the Grand River basin in 1962.

Of the 47 municipal sewage treatment facilities 18 provide minor or no treatment. Of the remaining 29 systems, 9 provide only primary treatment (sedimentation and sludge disposal) and 20 provide secondary treatment (primary treatment plus filtration or activated sludge). Major municipal sewerage facilities having connected populations of 5,000 or more are listed in Table II-24.

(2) Industrial. Industries with separate outfalls discharge approximately 15,000 pounds of BOD_5 daily to the streams of the Grand River basin. Major industrial waste sources in the Grand River basin are listed in Table II-25.

(3) Combined Sewers. It has been estimated that a quantity, equivalent to three to five percent of all untreated waste-water flow in combined sewer systems, is annually discharged to streams from overflows due to the fact that the sludge deposited in the sewers is flushed out by the storm flow.

Of the 47 communities with public sewer systems in the area only about eight have completely separate sewer systems. The types of sewer systems of the major municipal waste sources are listed in Table II-26.

TABLE II-26

Types of Municipal Sewer Systems
Major Municipal Waste Sources

Municipality	Type of Sewer System
Jackson	Combined
East Lansing	Separate and Combined
Lansing	Separate and Combined
Grand Ledge	Separate and Combined
Saint Johns	Separate and Combined
Hastings	Separate and Combined
Greenville	Separate and Combined
Ionia	Separate and Combined
Grand Rapids	Separate and Combined
Grand Haven	Separate and Combined

(4) Steam Power Plants. Thermal discharges from two steam generating stations at Lansing are particularly significant from a water quality standpoint. The temperatures of 90°F reported by the Michigan Water Resources Commission were measured prior to installation of additional generating capacity at Lansing. Unless control measures are taken, the temperature standards for fish and aquatic life will not be maintained.

(5) Agriculture and Land Runoff.

(a) Fertilizer. Estimates of fertilizer use in the Grand River basin are that approximately 11,400 tons of nitrogen and 22,600 tons of phosphate were used in 1959. The application of these are projected to increase by 260% and 161% respectively by 2020.

During 1963 and 1964 the Federal Water Quality Administration conducted a rural land runoff sampling study to assess the relative amounts of phosphorus and other substances transported to streams by rural runoff in the Lake Michigan watershed. Based upon the results of this study, it is estimated that there is an annual total soluble phosphorus runoff from rural land of about 100,000 pounds per year in the Grand River basin. Estimates of the total amount of phosphorus discharged to Lake Michigan from the Grand River basin are shown in Table II-27.

(b) Insecticides and Herbicides. Pesticide contamination is a matter of growing concern in some streams and surface waters. Pesticides are used extensively in agriculture to permit efficient production. Urban areas also use significant amounts in Dutch Elm disease and vector control programs. Even the runoff from individual lawns and gardens contributes substantially to the amounts of pesticides which have been found in water. Unfortunately, there is little or no information available as to the amounts that are used in the Basin.

(c) Sediment. Sedimentation from erosion of land has an undesirable effect upon water quality. Quantitatively it is the greatest pollutant. Water runoff causes excessive erosion from improperly managed agricultural and forested land. Erosion also occurs on such nonagricultural land uses as highway banks, bridge embankments and approaches, road culverts,

Table II-27 Water Quality - Grand River at Mouth
March 1963 - April 1964

Parameter	No. of Samples	Concentration (mg/l) Average	Range	Loading (lbs/year)
Phosphorus (P) (total soluble)	52	0.17	0.04-0.36	648,600
Ammonia Nitrogen (NH_3-N)	52	0.68	0.05-1.5	2,544,000
Nitrate Nitrogen (NO_3-N)	51	0.72	0.04-2.4	
Organic Nitrogen (Org-N)	52	0.77		
Total Dissolved Solids	51	350	275-570	
Total Suspended Solids	44	24	6-84	
Sulfates (SO_4)	52	74	56-100	
Chlorides (Cl)	52	42	19-67	
Silicon Dioxide (SiO_2)	52	5.3	2.5-17	
Calcium (Ca)	52	72	51-85	
Magnesium (Mg)	52	26	16-30	
Sodium (Na)	52	28	7.1-43	
Potassium (K)	52	2.8	2.1-3.9	
Alkyl Benzene Sulfonate (ABS)	52	0.28	0.11-0.73	
Copper (Cu)	52	0.14		
Cadmium (Cd)	52	*		
Nickel (Ni)	52	0.04		
Zinc (Zn)	52	*		
Chromium (Cr)	52	0.04		
Lead (Pb)	52	0.11		

and business, residential, and other construction sites.

(6) Ships and Boats.

(a) Commercial Shipping. The large number of vessels plying Grand Haven Harbor represents a considerable potential for pollution of the harbor waters. Among the possible sources of pollution are cargo spillage, dunnage, bilge waste, ballast water, fuel spills, garbage, and sanitary wastes. Uncontrolled discharges of these wastes can result in serious pollution problems to beaches, shore property, recreational waters, fish and aquatic life, and municipal and industrial water supplies.

Commercial shipping has increased significantly since the opening of the St. Lawrence Seaway in 1959. While all new vessels built since 1952 specifically for use on the Great Lakes have been equipped with waste treatment facilities, ocean-going ships generally have no provisions for waste treatment. The majority of these ocean-going vessels are designed to discharge sanitary wastes from multiple outlets.

The United States Public Health Service has established regulations governing vessel waste discharges in the Great Lakes based upon their legal responsibility for the interstate control of communicable diseases. Restricted areas have been established in which the discharge of sewage, or ballast or bilge water, from vessels is prohibited. Restricted areas include the water within a three mile radius of domestic water intakes. Additional controls were recommended by the conferees to the Four State-Federal Lake Michigan Enforcement Conference.

(b) Recreational Boats. In addition to commercial traffic, Grand Haven Harbor is also an important recreational boating center. About 4,000 recreational craft annually are passed through the Spring Bridge which joins Ferrysburg and Spring Lake. There are numerous marinas and boat clubs along the lower part of the Grand River. Many of the larger recreational craft are equipped with galley and toilet facilities which may discharge untreated or inadequately treated wastes to the harbor or lake waters. Oil and gasoline wastes, as well as garbage and sewage from onboard cooking and toilet facilities, are the major potential sources of pollution. The State of Michigan has recently adopted rules and regulations to control pollution from this source.

(7) Dredging. Maintenance dredging is done by the United States Army Corps of Engineers to maintain authorized navigation depths in Grand Haven Harbor. Dredged materials are disposed of in the deep waters of Lake Michigan.

Water quality surveys made in 1967 by the Federal Water Quality Administration showed significant evidence of pollution material in the bottom deposits of Grand Haven Harbor. Transfer of this pollutional material to Lake Michigan via the dredging process creates an additional zone of pollution in the lake.

Under Section 123(a) of the River and Harbor Act of 1970 (Public Law 91-611), the Corps of Engineers is authorized to construct, operate, and maintain contained spoil disposal facilities of sufficient capacity for a period not to exceed ten years, to meet requirements described in Section 123. Prior to establishing each such facility, the Corps shall obtain the concurrence of appropriate local governments and shall consider the views and recommendations of the U. S. Environmental Protection Agency and shall comply with the requirements set forth in Section 21 of the Federal Water Pollution Control Act (Public Law 84-660 as amended), and of the National Environmental Policy Act (Public Law 91-190).

c. Sources of Phosphorus.

(1) Transport to Streams and Lakes from Rural Lands. The amount of soluble phosphorus reaching streams from land runoff, in the Grand River basin, as estimated from samples taken on eight pilot watersheds, as previously discussed, is about 100,000 pounds annually. Although there are many factors which affect phosphorus contributions from rural areas, including methods of applying fertilizers, quantities applied, type of soil, topography, rainfall, land use practices, and soil cover, it is believed that the results obtained are reasonably representative of the Grand River basin.

(2) Municipal Sources. Domestic sewage is relatively rich in phosphorus compounds. Most of this phosphorus comes from human excreta and synthetic detergents. The amount of phosphorus released by human metabolic processes is a function of protein intake and for the average person in the United States, this release is considered to be about 1.5 grams per day. Synthetic detergent formulations contain large amounts of phosphorus. It is estimated that 2.5 grams of phosphorus per capita-day are discharged to sewer systems as a result of the use of synthetic detergents.

When the above per capita figures for phosphorus from human excreta and detergents are expanded to cover the entire sewered population of the Grand River basin, the quantity becomes quite large. Data from waste inventories show that 540,000 people were served by sewer systems in the Basin in 1962. It is estimated that a total of approximately 1,100,000 pounds of soluble phosphorus from humans and detergents are discharged to the waters of the Basin each year.

(3) Tributary Mouth Sampling. In addition to the land runoff sampling from the eight small sub-basins discussed above, sampling stations were established at the mouth of the Grand River. These stations were sampled intermittently for one year during the same period in which the land runoff stations were sampled.

Sampling at the mouth made it possible to estimate the total phosphoric load reaching Lake Michigan through the Grand River. It was determined that the River discharges 648,600 pounds of phosphorus to the lake annually.

SECTION III

PLAN A

1. SUMMARY OF PLAN A

Plan A includes waste treatment facilities adequate to permit attainment of the water quality standards adopted by the State of Michigan; preservation of streams and related land through the establishment of "valley preserves"; forty-two watershed development programs (fourteen of them with potential for early action, and twenty-eight with potential for future development); improvements for both commercial and recreational navigation; local flood protection; two multiple-purpose reservoir complexes of three pools each, on the Upper Grand River and the Red Cedar River, both upstream from Lansing; fourteen other multiple-purpose impoundments, most of which are small impoundments to serve recreation and fish and wildlife needs; accelerated land treatment for 481,200 acres of crop, pasture, and forest lands; and other non-structural programs to serve the needs of the people of the basin.

Provision for high levels of waste treatment throughout the basin is the primary and highest priority recommendation of the Coordinating Committee. The success of the other elements of the plan depends upon, and in fact is explicity predicated upon, the achievement of the water quality standards adopted by both the Federal government and the State of Michigan.

It is recommended that implementation of features of the structural plan other than waste collections, treatment, and disposal, be dependent on prior achievement of relevant State water quality standards.

2. WASTE COLLECTION, TREATMENT, AND DISPOSAL.

a. Water Quality Standards. Water quality standards relevant to this study are: (1) standards established by the State of Michigan for the intrastate Grand River and its tributaries; and (2) Federal-State standards for Lake Michigan (an interstate body of water) established pursuant to the Federal Water Pollution Control Act of 1965. Although it is not mandatory that the State of Michigan standards for the Grand River and tributaries be approved by the Federal government, they have nevertheless been accepted by mutual agreement as defining the objectives of the water quality enhancement program recommended by this study.

b. State of Michigan Water Quality Standards for the Grand River and Tributaries. The water quality standards promulgated by the Michigan Water Resources Commission for the Grand River and tributaries are as follows:

Water Supply

(1) All existing public water supply intakes in normal daily use will be protected for Domestic Water Supply at the point of intake. The following waters will be protected for Domestic Water Supply:

Grand River at Grand Rapids

Rogue River at Rockford

(2) All public waters will be protected for Industrial Water Supply.

Recreation

(1) All natural lakes will be protected for Total Body Contact. The following impoundments will be protected for Total Body Contact:

Name	Water Impounded or Used for Total Body Contact	County	Area to be Protected
Ada Lake	Thornapple River	Kent	From head of Ada Dam
Cascade Lake	Thornapple River	Kent	Upstream to headwaters of Cascade Lake (48th Street)
Fallasberg Dam	Flat River	Kent	
Grand River	Grand River	Ottawa	Eastmanville downstream to 160th Avenue
Grand River	Grand River	Kent	Plainfield Road Bridge downstream to lower limits of Comstock Riverside Park
Ionia Recreation Area	Sessions Creek	Ionia	T6N, R3W, NW 1/4 of Sec. 3 downstream to dam
Lake Geneva	Lookingglass River (not impounded)	Clinton	
Lake LeAnn	Grand River	Hillsdale	
Lake Victoria	Alder Creek	Clinton	
Manitoon Lake	Unnamed Creek	Shiawassee	
Moore's Park Impoundment	Grand River	Ingham	Waverly Rd. downstream to dam
Sleepy Hollow Reservoir	Maple River	Clinton	Jason Rd. downstream to dam
Springbrook Lake	Springbrook Ck.	Shiawassee	
Thornapple Lake	Thornapple River	Barry	
Webber Dam Impoundment	Grand River	Goodwin Rd.	Downstream to dam

There are certain waters which, due to physical hazards, have not been designated for total body contact. If these waters in the future become suitable for this use through removal of these hazards the waters will be reconsidered for total body contact use.

(2) All public waters will be protected for Partial Body Contact.

Fish, Wildlife, and Other Aquatic Life

The Michigan Department of Natural Resources has recommended to the Michigan Water Resources Commission several reaches of streams in the Grand River basin for water quality designations. This list of streams and the reaches of each are described in paragraph 2e, Fish and Wildlife, of Section V herein.

Agricultural

All public waters will be protected for Agriculture.

The above designated uses are not intended to be applicable to drainage ditches. However, Act 245 of the Public Acts of 1929, as amended, prohibits unlawful pollution of any waters of the State of Michigan.

It is the policy of the Michigan Water Resources Commission to abate existing pollution and to prevent future pollution in all waters of the State, including drainage ditches.

There are stretches of streams within the Grand River drainage area where natural water quality may at times be lower than certain parameters of water quality standards specified for a designated use. However, it is intended that the water quality for a designated use be maintained except in those instances where because of natural conditions the quality is lowered.

The water quality standards for the designated use areas shall not apply during periods of authorized dredging for navigation purposes and during such periods of time when the after-effects of dredging degrade water quality in areas affected by dredging. (Water quality standards for the designated use shall apply in areas utilized for the disposal of spoil from dredging operations).

Where the waters of the Grand River Basin are classified under more than one designated water use, it is intended that the most restrictive individual standards of the designated water uses shall be adhered to.

The use designations adopted by the Michigan Water Resources Commission are in all cases minimal and are not to be interpreted as a license to cause injuries declared to be unlawful by Act 245, Public Act 1929, as amended, or to do any other unlawful act.

The Tolerant Fish, warm-water species use designation will apply only until January 1974, by which time the waste disposal situations involved will have been placed before the Michigan Water Resources Commission for critical reconsideration, with a view toward the application of higher quality use designations.

c. Interstate Water Quality Standards Impact for Tributaries to Lake Michigan. Water quality control planning in the Grand River Basin must consider both intrabasin requirements and the effects of the Grand River on Lake Michigan and downstream waters. Not only have interstate standards been established for Lake Michigan, but there is an ongoing Federal-State enforcement action for the Lake and its tributary basin. Applicable provisions of the interstate standards and their associated implementation plans, as well as initial and subsequent actions of conferees and the Secretary of the Interior in the enforcement proceedings, are binding upon a water quality control program for the Grand River Basin.

d. Municipal Waste Treatment Needs. The immediate goal in the treatment of municipal wastes is the provision of biological (secondary) treatment or its equivalent at each waste treatment plant. Such treatment is the minimum considered adequate in terms of present technology. This need is especially important in those areas where consideration is being given to low flow augmentation to assist in maintaining water quality standards. Augmentation cannot be considered as a substitute for secondary treatment.

There is a program underway to increase total phosphorus removal to at least 80% as recommended by the Four-State Federal Enforcement Conference on the Pollution of Lake Michigan and its Tributary Basin. All municipal waste treatment facilities in Michigan are required to provide waste disinfection on a year around basis.

COMMISSION OBJECTIVE

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION AND THE DEPARTMENT OF THE INTERIOR THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS; OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED; OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTERSTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

Table III-1

WATER QUALITY STANDARDS

PARAMETERS / WATER USES	1 COLIFORM GROUP (Organisms/100 ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A WATER SUPPLY (1) DOMESTIC Such as drinking, culinary and food processing.	FOR GREAT LAKES & CONNECTING WATERS: The monthly average shall not exceed 2000 nor shall 20% of the samples examined exceed 2000. FOR INLAND WATERS: The monthly average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium[6]: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-B.
(2) INDUSTRIAL Such as cooling and manufacturing process.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
B RECREATION (1) TOTAL BODY CONTACT Such as swimming, water-skiing and skin-diving.	The average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 100.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
(2) PARTIAL BODY CONTACT Such as fishing, hunting, trapping, and boating.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
C FISH, WILDLIFE AND OTHER AQUATIC LIFE Such as growth and propagation.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	At the average low river flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained for: Intolerant fish - cold water species: Not less than 6 at any time. Intolerant fish - warm water species: Average daily DO not less than 5, nor shall any single value be less than 4. Tolerant fish - warm water species: Average daily DO not less than 4, nor shall any single value be less than 3. At greater flows the DO shall be in excess of these values.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D AGRICULTURAL Such as livestock watering, irrigation and spraying.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Not less than 3 at any time.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use.
E COMMERCIAL AND OTHER Such as navigation, hydroelectric and steam generated electric power and uses not included elsewhere in standards.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.

* For the Great Lakes and connecting waters no heat load in sufficient quantity to create conditions which are or may become injurious to the public health, safety or welfare; or which are or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which are or may become injurious to the value or utility of riparian lands; or which are or may become injurious to livestock, wild animals, birds, fish or aquatic life or the growth or propagation thereof.

Table III-1 (Cont'd)

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates, and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 * TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
FOR GREAT LAKES & CONNECTING WATERS: Total Dissolved Solids: The maximum shall not exceed 200. Chlorides: The monthly average shall not exceed 50. A monthly average of 10 is a desirable limit where existing conditions are less than 10. FOR INLAND WATERS: Total Dissolved Solids: Shall not exceed 500 as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 10°F.	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha-emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum.	Maintained within the range [illegible] with a maximum ind[illegible] variation [illegible] within [illegible]	Standards to be established when information becomes available on deleterious effects.
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	(Ambient / Allowable increase / Maximum limit) Intolerant fish - cold water species: 32° to nat. max. / 10° / 70° Intolerant fish - warm water species: 32° to 35° / 15°; 36° to nat. max. / 10° / 85° Tolerant fish - warm water species: 32° to 59° / 15°; 60° to nat. max. / 10° / 87°	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0).	Standards to be established when information becomes available on deleterious effects.
Less than 700 dissolved minerals. Maximum percentage of sodium 60% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ when the bases are expressed as milliequivalents per liter.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha-emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.

There are forty seven municipal treatment plants in the Grand River basin, listed in table III-5.

e. Industrial Waste Treatment Needs. The major industries with separate waste outfalls were listed in Table II-25. The equivalent of secondary waste treatment is the minimum degree of treatment required.

f. Combined Sewer Overflow Control. The need for solutions to the problems caused by overflows from combined sewer systems is pressing and is receiving much current attention. The Water Quality Act of 1965 established a four-year program of grants and contract authority to demonstrate new or improved methods to eradicate the problems of combined sewer overflows.

While economically feasible methods of solving the problems are being developed, existing combined sewer systems should be patrolled and overflow regulating structures should be adjusted to convey the maximum practicable amount of combined flows to and through waste treatment facilities. Combined sewers should be prohibited in all newly developed urban areas and should be separated in coordination with urban renewal projects.

g. Plant Operation. Proper plant operation must follow proper plant design in order to reach the goals of water pollution control efficiently. The importance and value of proper plant operation must be emphasized at all levels of public authority. Effective operation can be encouraged by means of a routine inspection program. Inspections should be conducted by the appropriate State agency on at least an annual basis for the small and medium-sized plants and at least twice a year for the large plants.

The Michigan Department of Health administers a mandatory sewage treatment plant operators' certification program. State-sponsored operator training programs are also a useful tool for elevating the level of overall plant performance. Today, with increasing activity in the field of water pollution control at the Federal, State, and local levels, operator training courses should be conducted at least annually. The Michigan program, consisting of annual training on a regional basis, compares favorably with the training programs sponsored by other States.

Table III-2

CURRENT MUNICIPAL WASTEWATER
TREATMENT WORKS

Community	County	Population	Plant Type
Ada Twp.	Kent		Lagoon
Belding	Ionia	5,000	Lagoons
Carson City	Montcalm	1,201	Aerated lagoons
Cedar Springs	Kent	1,768	Lagoons
Coopersville	Ottawa	1,584	Trickling filter
DeWitt	Clinton	1,238	Primary
Delhi Twp.	Ingham	5,000	Primary
Delta Twp.	Eaton		Primary
East Lansing	Ingham	37,800	Activated * sludge
Eaton Rapids	Eaton	4,300	Primary
Edmore	Montcalm	1,234	Lagoon
Fowler	Clinton	854	Trickling filter
Fowlerville	Livingston	1,674	Lagoons
Grand Haven	Ottawa	11,700	Primary
Grand Ledge	Eaton	5,500	Primary
Grand Rapids	Kent	220,300	Activated * sludge
Grandville	Kent	8,500	Activated sludge
Grant	Newaygo	732	Trickling filter
Greenville	Montcalm	7,200	Primary
Hastings	Barry	7,000	Primary
Ionia	Ionia	6,500	Primary
Jackson	Jackson	48,500	Activated sludge
Kent City	Kent	617	Lagoon
Kent Co. Byron Center	Kent		Lagoons
Kent Co. Airport	Kent	5,000	Lagoons
Lansing	Ingham	122,000	Activated * sludge
Leslie	Ingham	1,807	Primary
Lowell	Kent	2,600	Septic tank
Mason	Ingham	5,000	Activated sludge

Table III-2 (Cont'd)

Community	County	Population	Plant Type
Middleville	Barry	1,196	Imhoff tank
Nashville	Barry	1,525	Primary
Ottawa Co Grand Valley State College	Ottawa		Lagoons
Ottawa Co. Wright T. Marne	Ottawa		Lagoon
Ovid	Clinton	1,505	Lagoon
Portland	Ionia	3,500	Primary
Potterville	Eaton	1,028	Lagoon
Rockford	Kent	2,074	Primary
Sand Lake	Kent	400	Lagoon
Saranac	Ionia	1,081	Aerated lagoon
Sparta	Kent	3,000	Trickling filter
Spring Lake	Ottawa	2,063	Imhoff tank
St. Johns	Clinton	5,900	Trickling filter
Stanton	Montcalm	1,139	Lagoon
Webberville	Ingham	664	Lagoon
Williamston	Ingham	2,214	Primary
Woodland	Barry	374	Trickling filter
Wyoming	Kent	52,000	Trickling filter *

* Plant also serves one or more other communities.

Table III-3

MICHIGAN COMMUNITIES SERVED BY OTHER WASTEWATER TREATMENT SYSTEMS

Community	County	Population	Owner of Facility
Byron Twp. (part)	Kent		Wyoming
East Grand Rapids	Kent	11,300	Grand Rapids
Gaines Twp.	Kent		Wyoming
Grand Rapids Twp.	Kent		Grand Rapids
Kentwood (part)	Kent		Grand Rapids
Kentwood (part)	Kent		Wyoming
Walker	Kent	8,271	Grand Rapids

Table III-4

MUNICIPAL WASTE TREATMENT NEEDS

Municipality	Receiving Stream	County	Type of Pollution Control Facility Required	Estimated Total Cost 1968	Population Served
Caledonia	Thornapple River	Kent	Lagoon	120,000	800
Casnovia	Ball Creek	Muskegon	Lagoon	100,000	500
Dansville	Deer Creek	Ingham	Lagoon	200,000	1,000
Delta Twp.	Grand River	Eaton	Expansion + Interceptor	2,000,000	20,000
Delhi Twp.	Grand River	Ingham	Secondary	1,500,000	25,000
East Lansing	Red Cedar	Ingham	Tertiary Phosphate removal	3,000,000	80,000
Eaton Rapids	Grand River	Eaton	Secondary	500,000	4,500
Fowler	Peet Creek	Clinton	Expansion Phosphate removal	160,000	
Grand Haven	Grand River	Ottawa	Secondary	820,000	12,500
Grand Ledge	Grand River	Eaton	Secondary	294,000	6,000
Grand Rapids	Grand River	Kent	Phosphate removal	400,000	265,000
Greenville	Flat River	Montcalm	Secondary	500,000	8,100
Hastings	Thornapple River	Barry	Secondary	519,000	8,500
Hubbardston	Maple River	Ionia	Lagoon	95,000	400
Ionia	Grand River	Ionia	Secondary	605,000	7,500
Jackson	Grand River	Jackson	Tertiary	1,500,000	50,000
Kentwood	Grand River	Kent	Interceptor	1,600,000	15,000
Lansing	Grand River	Ingham	Tertiary		180,000
Leslie	Huntoon Creek	Ingham	Secondary	250,000	3,000
Lowell	Grand River	Kent	Lagoon	690,000	3,300
Mason	Grand River	Ingham	Tertiary	400,000	6,700
Nashville	Thornapple River	Barry	Secondary	268,000	2,000
Ovid	Maple River	Clinton	Lagoon	160,000	1,700
Pewamo	Stony Creek	Ionia	Lagoon	100,000	400
Portland	Grand River	Ionia	Secondary	210,000	400
St. Johns	Hayworth Creek	Clinton	Tertiary		6,500
Summit Twp.	West Jackson Improvement Drain	Jackson	Interceptor	600,000	20,000
Walker	Tallman Creek	Kent		2,560,000	12,200
Williamston	Red Cedar River	Ingham	Secondary	420,000	3,500

Table III-4 (Cont'd)

Municipality	Receiving Stream	County	Type of Pollution Control Facility Required	Estimated Total Cost 1968	Population Served
Wyoming	Grand River	Kent	Phosphate removal	100,000	60,000
Ashley	Ashley Drain	Gratiot	Lagoon	105,300	800
Ravenna	Crockery Creek	Muskegon	Lagoon	300,000	1,200
Montcalm C.C.	Flat River	Montcalm	Secondary	210,000	1,000
Gaines Twp.	Plaster Creek	Kent	Secondary	95,600	400
DeWitt	Looking Glass River	Clinton	Secondary	161,000	2,500
Grandville	Grand River	Kent	Interceptor	223,900	10,000
Dimondale	Grand River	Eaton	Lagoon	348,000	3,000
Vermontville	Thornapple River	Eaton	Lagoon	109,000	1,000
Wright Twp.	Sand Creek	Ottawa	Lagoon	112,500	700
Lake Odessa	Jordan Lake	Ionia	Expansion	359,000	4,000
Hudsonville and Georgetown Twp.	Grand River	Ottawa	Interceptor	1,132,000	27,500
Perry	Spaulding Drain	Shiawassee	Lagoon	166,000	1,500
Mulliken	Cryderman Creek	Eaton	Lagoon	215,000	900
Maple Rapids	Maple River	Clinton	Lagoon	109,200	800
Sparta	Rogue River	Kent	Expansion	361,600	4,000
Westphalia	Stony Creek	Clinton	Lagoon	60,300	700
Carson City	Fish Creek	Montcalm	Lagoon	183,500	2,800
Laingsburg	Looking Glass River	Shiawassee	Lagoon	115,300	1,300
Parma	Sandstone Creek	Jackson	Lagoon	90,000	800
Grass Lake	Grass Lake Drain	Jackson	Lagoon	177,000	1,200
Middleville	Thornapple River	Barry	Lagoon	356,300	3,000
Blackman Twp.	Grand River	Jackson	Interceptor	129,700	1,500
Cascade Twp & Grand Rapids Twp.	Grand	Kent	Interceptor	652,000	19,100
Leoni Twp.	Grand River	Jackson	Interceptor	791,000	17,400

Monthly operation reports should continue to be submitted to the Michigan Water Resources Commission from each municipal and industrial waste treatment facility. These reports should contain sufficient information to describe waste treatment efficiency and the quality and quantity of the effluent discharged to the waters of the Basin.

h. Monitoring. The maintenance of desirable water quality on a continuing basis calls for a routine monitoring program covering the significant water quality parameters at strategic points.

The overall monitoring program should be designed to identify all wastes discharged into the waters of the Basin and adjacent waters of Lake Michigan and should serve to indicate trends in water quality and the need for additional water quality improvement measures.

As part of an overall monitoring program, efforts are needed to assess the problems associated with land use practices in the Grand River Basin. The use and management of land has a profound effect on water quality. Sediment resulting from erosion processes is not only a physical pollutant in streams and lakes, but also provides transport for other pollutants. Reliable data concerning pesticide and fertilizer application rates on a yearly and seasonal basis in each county, as well as investigation and studies on controlled feed lot drainage throughout the Basin, would be helpful in identifying potential water quality problem areas.

Fourteen local governmental units started a cooperative stream monitoring program in June, 1968 under the sponsorship of the Michigan Grand River Watershed Council. Forty one stations were initially selected for the program. By the end of 1970, fifteen governmental units were in the program and the Center of Environmental Studies, Jackson Community College became a contributor. The contributors were sampling and testing approximately 100 stream and lake locations.

The basic program is monitoring every station, once a month on a given day of the month to assure a comprehensive analysis of the basin at one time. Each station is tested for temperature, dissolved oxygen, bio-chemical oxygen demand, chlorine, and the hydrogen ion. About one-half the stations are also tested for coliform, phosphate and nitrogen, and a few stations are tested for heavy metals.

All samples are drawn and tested according to standard procedures, and the data is stored in the Storet computer under the auspices of the Federal Water Quality Administration.

The program has provided meaningful information to the Council. However, plans are being developed to increase the number of governmental participants, increase the number of parameters being tested, increase the frequency of tests, incorporate flow data to determine "loading" on the stream, and to implement automatic monitoring connected to a centralized storage center.

i. The State of Michigan Water Pollution Control Program. The Federal Water Pollution Control Act recognizes the primary responsibility of the States in the control and prevention of water pollution. The effectiveness of a State program, however, is dependent upon adequate funds and personnel.

The State of Michigan has achieved commendable success in the control of water pollution with the staff and funds available. However, even though much has been accomplished by the State in controlling conditions, much remains yet to be done. In 1964, the Public Administration Service prepared a survey report for the Public Health Service concerning the budgeting and staffing of State programs. This report contains suggested guidelines for use in evaluating the adequacy of State water pollution control programs. This report suggests a minimum total staff level of 110 persons and a desirable total staff level of 171.

In view of the water pollution control problems still existing in the Basin, consideration should be given to an accelerated program to match the needs for clean water for all legitimate uses. An accelerated State water pollution control program utilizing fully the resources and programs of the Federal Water Pollution Control Administration will ensure the earliest possible accomplishment of our common goal - more effective use of our water resources.

3. The Concept of a Valley Preserve.

a. Definition. A valley preserve is a nonstructural device for managing water resources through the preservation of flood plain land as a green belt. Where needed to protect existing structures or to confer other benefits, measures such as levees, flood control reservoirs, and channel improvement may be recommended in conjunction with valley preserves.

The concept of a valley preserve is not new, but the concept has typically in the past been applied to much smaller areas than the Grand River basin. Typical examples of small valley preserves are found within the State of Michigan. In Wayne County, Rouge Park and Hines Drive are well developed flood plains devoted to meeting needs of the Detroit metropolitan area. Potter Park on the Red Cedar River in Lansing is another example of a small valley preserve. These parks have very high use rates, and their immediately adjacent areas are aesthetically pleasant with high quality residential units.

Valley preserves could be managed by Federal, State, basin watershed council, or county authority, except that present institutional powers and policies would need to be changed.

It is the recommendation of Plan A that the flood plains of the Grand River be managed as a valley preserve from the mouth of the river to the proposed Onondaga dam, and that portions of the flood plains of the Maple, Rogue, Thornapple, Flat, Lookingglass, and Red Cedar rivers and Prairie, Crockery, Sand, Buck, Plaster, and Sycamore creeks be managed as valley preserves. The valley preserves would consist of designated areas on one or both banks of a stream, with the provision that continuity be maintained.

b. Objectives. Designation of the specific areas to be included within the valley preserves would be guided by the attempt to achieve the following principal objectives: (1) the preservation of ecologically significant areas worthy of preservation in their natural state; (2) the management of areas capable of satisfying personal leisure-time needs for outdoor activities such as hunting, fishing, camping, and picnicking; and (3) the protection of areas within the flood plain to preclude unwise construction of buildings subject to flood damage.

Recreation: Recreation needs are diversified such that the size of the valley preserve developed is not restrictive. Large areas may be developed that could encompass all aspects of recreation, while only a few acres are necessary to develop a single use such as a roadside park, or where the topography is suitable, to develop a ski or sled slide.

Fish and Wildlife: The ways of meeting hunting and fishing needs are not as flexible as those for recreation needs because rather extensive tracts of land and water are needed. The smallest game area presently managed by the State is about one square mile, while the largest is about thirty square miles.

c. Relation of the Valley Preserve to Land Configuration and to Current Land Use. Present land use patterns would inevitably impose some constraints upon implementation of the valley preserves.

Subdivisions: Improved subdivided tracts adjacent to the streams would remain intact, subject to certain regulations. Existing buildings and new buildings would require installation of sump pumps in basements if not already present or specified. Roads would be raised to certain prescribed elevations. First floors of new buildings would be at prescribed elevations; all occupied buildings would have their sanitary wastes piped to sewage treatment and disposal facilities.

Highways: These would be utilized as boundaries wherever possible. They serve the purpose of providing access to the Valley Preserve area and also enhance the land development for residential use as a result of

the valley preserve along the highway. Those residences existing in groups along the highways (strip housing) in the valley preserve would not be purchased wholly. They would be allotted lots up to 200 feet deep, and their value would be enhanced by the presence of the Valley Preserve.

Mineral Pits: Mineral pits would remain in production. However, they would be required to provide adequate sewage and pollution treatment facilities for all production features, processes, and operations.

Land Blocks: Land blocks would be used in designating areas when available. This would avoid excessive legal and technical costs incurred in subdividing land blocks.

Topography: Where steep river banks are encountered and needs do not exist or are satisfied through development of another area, only 50 feet right-of-way areas would be purchased. These right-of-way areas would be reduced to minimum 10 foot widths through city limits. It is intended that the right-of-way areas would be utilized as hiking trails.

d. Management. Elements of the management program for valley preserves consist of developing the water and related land resources for the intended use and the continual maintenance of these resources. Proper development of valley preserves consists of providing appropriate facilities for the intended functional use of the area while preserving the natural setting of the area. Facilities required for each designated activity are briefly described below:

Swimming: Beach areas would be provided where bank slopes and topography are suitable for their development. Hydraulic structures such as jetties, groins, or check dams may be constructed to develop and maintain these facilities. In addition public facilities for showering, locker rooms, rest rooms and public access and parking areas would be developed. These facilities would be equipped with adequate safety features. It is noted that these facilities may also be used for ice skating during the winter months under proper safety conditions.

Boating: Public access, parking, and launch facilities would be provided for designated boating areas. In addition, proper sanitation facilities would be provided for boat users. Each site would also be provided with proper safety equipment.

Camping: Areas designated for camping would be provided with public access with adequate service features such as separable mobile and non-mobile camp sites. Each area would be serviced by adequate sanitation facilities. In addition, the mobile camp site would also be equipped with electrical outlets. Each site should have access to facilities for family participation activities such as volleyball, shuffleboard, and horseshoes. Each site would be provided with proper emergency equipment against health, fire and natural hazards.

Hiking: Hiking facilities would consist of public access and parking areas. Trails would be designated as to functional use such as bike, mobile, horse, sled, or nature. Trails would be properly marked for direction as well as information. Sanitation and first aid equipment would be provided at designated areas within reasonable distance of all trail locations. Brochures indicating trail functions and points of interest would be made available.

Picnicking: Public access and parking areas as well as proper sanitation facilities would be provided. Adequate outdoor cooking grills and tables would be provided. Adequate facilities should also, where possible, provide for development of family recreation activities such as softball, volleyball, and horseshoes.

Hunting: Facilities would consist of adequate public access to the hunting areas. Brochures would be provided indicating significant landmarks. An attempt would be made to retain the natural characteristics of these areas.

Fishing: Adequate public access sites with boat launching and parking facilities would be provided. Check dams might be constructed to maintain level pools at desirable fishing sites. Areas would also be designated as shoreline fishing sites.

e. Benefits. Market-valued benefits are benefits realized by recreation and fish and wildlife users. They are derived as a direct use of the water and related land resources. Methods are presently available to evaluate them.

The nonmarket-valued benefits derived from implementing development of a valley preserve would be significant. Land enhancement, flood control, water quality control, and aesthetic factors comprise the greatest amount of nonmarket-valued benefits. Each of these factors is briefly described hereinafter:

Land Enhancement: Land enhancement would increase significantly as a result of adjacent lands being closely located to recreational areas while remaining reasonably close to urban areas. Studies at the University of Kentucky on effects on property tax evaluations of development of reservoirs indicate that for tax areas lost through government ownership, the land valuation per acre increased on the remaining portion of the county such that the ability of local governments to extract tax revenues was retained. After a short period of time, tax revenues substantially increased due to economic growth induced by the presence of the reservoir or facility.

Flood Control: Flood control nonmarket-valued benefits would be derived as a result of preventing commercial and residential development from taking place within the area subject to periodic flooding.

Water Quality: Water quality nonmarket-valued benefits would be derived by averting urbanization of the flood plain, and thereby decreasing sediment loads.

Aesthetics: Nonmarket-valued aesthetic benefits would result from preserving the water and land resources of the Basin or restoring them to their natural state.

f. Implementation. Recommendations regarding implementation of the valley preserve concept are to be found in the Summary Report. The recommendations relate to: (1) the appropriate locus of responsibility for implementation; (2) sources of funds; (3) methods of setting priorities for acquisition and development; (4) methods of acquisition and control; and (5) techniques for coordinating valley preserve development with other local community development plans.

g. Proposed Extent. The proposed extent of the valley preserve system included in Plan A is shown on Plates Q-1 and Q-2. Most of the Grand River banks retain the flows of annual frequency only. Plates Q-3 thru Q-22, which show the individual reaches of the Plan A valley preserve system, include the areas that would be inundated by the intermediate regional flood (1947 ± feet). These areas should be included as part of the land that would comprise the valley preserve system of Plan A.

The proposed valley preserve reaches incorporated into Plan A consist of the following: (1) the main stem of the Grand River from the proposed Onondaga Dam to the mouth; (2) Prairie Creek from the proposed Prairie Creek Reservoir to the confluence with the Grand River; (3) Fish Creek from the proposed Fish Creek Reservoir to the confluence with the Grand River; (4) the North Branch and main stem of Crockery Creek from the proposed Ravenna Reservoir to where the Crockery Creek confluences with the Grand River; (5) Sand Creek from the proposed Sand Creek Reservoir to the confluence with the Grand River; (6) Buck Creek from where it rises to its confluence with the Grand River; (7) Plaster Creek from the boundary line between Sections 16 and 17 of Gaines Township to the confluence with the Grand River; (8) the Rogue River from the Rogue River State Game Area to the confluence with the Grand River; (9) the Thornapple River from the Barry-Eaton County Line to the confluence with the Grand River; (10) the Flat River from the Pine-Montcalm Township Line to the confluence with the Grand River; (11) the Lookingglass River from the Clinton-Shiawassee County Line to the confluence with the Grand River; (12) the Red Cedar River from the proposed Okemos Dam to the confluence with the Grand River; and (13) Sycamore Creek from the boundary line between Sections 16 and 21 of Vevay Township to the confluence with the Red Cedar River. Valley preserve borders would follow the flood plains as closely as judicious property lines lend themselves to it.

4. The Grand River as a Valley Preserve (Number 1).

a. Reach 0-1, Grand Haven to Ottawa-Kent County Line. From the Ottawa-Kent County Line, the Grand River flows west by north in a meandering course, 34 river miles to Lake Michigan, bisecting Grand Haven on the shore. The normal flow is contained between banks 10 to 18 feet high. Several bayous of importance branch off laterally from both sides. The adjacent land varies from level to very hilly with elevations ranging from 578 to 630 feet; sand dunes line the Lake Michigan shore. Poorly drained areas, swamps and woodland flank the entire reach; the soil is mainly sand of low fertility. Virtually every year the river rises and inundates adjacent lands. The flood plain is outlined on Plate C-3; this is the land that is recommended in this reach for a valley preserve with development and management as before outlined. It is a populous reach of the river.

b. Reach 1-2, Ottawa-Kent County Line to Rogue River. From the confluence of the Rogue and Grand Rivers, the Grand sweeps in a well defined channel on a generally southwestwardly course through Grand Rapids to the Ottawa-Kent County Line. This is in a densely populated section. The normal flow is between banks varying from 5 to 20 feet high on both sides. The land adjacent to the river is level, interrupted with a few hills in the lower part of the reach. Swamps and poorly drained areas flank the main stem outside Grand Rapids and the soil of the flood plain is mainly sand of low fertility. Almost every year the river flow overtops the river banks and inundates adjacent lands. The flood plain that would be inundated in this reach and is recommended for a valley preserve is outlined on Plate C-4.

c. Reach 2-3, Rogue River to Thornapple River. From the confluence of the Thornapple and Grand Rivers, the Grand flows northwesterly to the confluence of the Rogue River. The river channel is well defined between banks 10 feet high and falls from elevation 613 to 609 feet over the 12 river miles of the reach. The land immediately adjacent to the river which constitutes the flood plain is relatively level, interrupted by swamps in the lower half of the reach; the soil is mainly deep sands of low fertility. Some hardwood forestation extends over this entire reach. Population is sparse; floods occur about every other year in portions of this reach. The flood plain that would be inundated in this reach and is recommended for a valley preserve is shown on Plate C-5.

d. Reach 3-4, Thornapple River to Kent-Ionia County Line. From the confluence of the Flat and the Grand Rivers, at Lowell, the Grand flows west 4.5 miles, then northwest 3.7 miles to the confluence of the Thornapple and Grand Rivers at Ada. In this reach, 8.2 river miles long, the Grand drops four feet, from 617 to 613 feet elevation at normal flow. The normal channel is well defined between banks from 5 to 10 feet high; the flood plain is flat with swamps in the middle of the reach. The soils are sandy and of low fertility; some woodlands are in the lower one-fourth. Ada and Lowell are the centers of population; elsewhere the reach is sparsely populated.

About every two years, the river flow overtops the banks and inundates the adjacent flood plains. The flood-plain that is recommended for a valley preserve is shown on Plate O-6.

e. Reach 4-5, Kent-Ionia County Line to Prairie Creek. From the confluence of Prairie Creek and the Grand River, one mile east of Ionia, the Grand flows southwesterly to the Flat and Grand Rivers' confluence at Lowell. The Grand, in this 20 river mile reach, ranges from 100 to 300 feet in width between primary banks which rise 6 to 18 feet above the river bed. Stream banks rise from a minimum elevation of 625 feet. The normal river course is torturous and interesting, cuts through level flood plains, from 1/2 to 1 mile wide. There are no rapids; the river falls only 1/2 foot per mile. Extensive swamps and woodlands occur in the middle half of the reach. Beyond the flood plains, the countryside is hilly, rising to elevations of as much as 840 feet; woodlands dot these uplands. The flood plain soils are sand, silt, and clay; the stream bed is alluvium. Outside of Lowell and Ionia, the reach is sparsely populated. At Lowell floods occur once every three years; it is estimated that portions of the flood plain are inundated every year. The flood plain that is recommended for a valley preserve is shown on Plate O-7.

f. Reach 5-6, Prairie Creek to Portland Municipal Dam. From Portland at river mile 113 of the Grand River, the Portland Valley Preserve extends four miles northwest to the Portland Municipal Dam at river mile 109. Continuing from here, the Grand winds in wide meanders 14.5 river miles, north-westerly to Muir, and descends 64 feet in elevation.

The normal channel is well defined and varies from 200 to 2,100 feet in width. River banks rise as high as 100 feet above the water; steeply downstream on the meanders, less sharply on the upstream sides. The uplands are hilly and undulatory; lands immediately adjacent to the river are sandy loams of moderate fertility, devoid of swamps.

From Muir the Grand flows west and a little south 4.7 river miles to its confluence with Prairie Creek, descending 10 feet in elevation. The normal channel is well defined between primary banks 8 to 10 feet high. Broad, flat plains 1/2 to 1 mile wide extend south from the Grand Trunk Western Railroad track which parallels the north river bank. The flood plain soil is sandy loam of medium fertility with scattered swamps. Hilly uplands, dotted with woodlands, rise as much as 150 feet in elevation on gentle slopes from either side. Outside of Lyons and Muir the reach is thinly populated. The flood plain outlined on Plate C-8 is recommended for a valley preserve. As can be seen from this drawing, only the part from Muir to Prairie Creek has extensive lands that are frequently inundated - probably once a year.

g. Reach 6-7, Portland Municipal Dam to Ionia-Clinton County Line. West of the heart of the village of Portland 1.5 miles, and north 0.5 miles, is the Portland Municipal Dam across the Grand River. From this dam, the Grand sweeps east and south, upstream, in a wide meander through Portland. Leaving the village, the river continues south, upstream, five miles, then turns east generally, and pursues its course four miles to the east Ionia County Line. The path of the river is typically tortuous with wide meanders traversing the axis of its general course. The actual length of this reach is 22 river miles.

Flood plains varying in width from 20 to 400 feet flank the river here. From these the uplands rise on either side 60 to 80 feet at varying slopes, precipitous on the downstream banks of the meanders, gentler at the upstream sides. Flowing from the east, the Lookingglass River in a valley similar to that of the Grand, joins the latter river at the center of Portland.

The normal flow of the Grand here does not fluctuate greatly. Seasonal variations in river stage are about five feet and the river overflows its banks once a year usually.

The soils of the valley are glacial drift, mostly gravel, and well drained; however at present they are unproductive. The general

topography of this area is undulating and hilly, ranging from 690 to 820 feet in elevation.

It is recommended that this river valley from the Portland Municipal Dam, river mile 109, to the Ionia County Line, river mile 131.2, together with the valley of the Lookingglass River upstream to mile 1, be developed as a valley preserve.

This project is proposed to provide multi-purpose usage, primarily for recreation and fish and wildlife needs. Secondary benefits from flood prevention, improvement of water quality and land value enhancement would follow also. It is proposed to develop the area extensively for land recreation use supplemented by aquatic activities.

Management of the land would be such that urbanization of the valley would be discouraged thus minimizing flood drainage and bettering water quality. Land values adjacent should rise as a result of the development coupled with the proximity of the expanding Lansing area, and the excellent access highways.

The total estimated cost to develop the valley preserve system is based on (1) 1968 price levels; (2) the total land area included in the system; (3) real estate values of lands that would be effected; and (4) facility costs including those for parking, shelter buildings, boat launchings, hunting, hiking, and picnicking. The cost to develop the preserve per mile is estimated to be $70,000. The total cost is estimated at $1,5000,000. Annual cost to operate and maintain is estimated at $60,000. Benefits from recreation are estimated to be $60,000 annually and the benefit/cost ratio is 1.0.

In harmony with the valley preserve the village of Portland has advanced certain proposals for improving the recreational and hydro-electric power situation there. These contemplate dredging and widening the river reservoir upstream of the Municipal Dam. To eliminate rapids in the Lookingglass and Grand Rivers that would ensue from this dredging, it is proposed to install a dam in the Grand upstream from Bridge Street. The village states that 600 kw of hydro-electric power would be made available from this damming of the Grand, and that the waters upstream from

the dam would be improved. A plan of the Portland Valley Preserve is shown on Plate Q-9.

h. Reach 7-8, Ionia-Clinton County Line to Lansing. Through Lansing the Grand flows north from Main Street 2 miles to the outskirts, then turns west in an irregular course 12.6 miles to Grand Ledge. The normal channel in this part of the reach is well defined. In Lansing the flood plain is rather narrow and is flanked by gradually sloping banks 30 to 40 feet high. Proceeding west the channel is incised increasingly deeper until at Grand Ledge the normal banks are as much as 60 feet above normal water. The flood plain in this part of the reach is narrow, 400 to 1,000 feet wide most of the way. The uplands are hilly, rising 80 feet or more on gradual slopes. From Grand Ledge, the Grand pursues a generally northwest course with three wide meanders to the Ionia-Clinton County Line. The river falls 22 feet in 8.7 river miles, in a deeply incised channel. Banks 60 feet high contain the river; precipitous on the downstream of meanders, less steep on the upstream. The topography of hilly, undulatory uplands is typical from Lansing to the Ionia-Kent County Line. The soils in the constricted flood plain are loam, silty loam, and silty clay, of low to medium fertility. The outline on Plate Q-10 shows the area that is recommended for the valley preserve. The entire reach is 22 river miles long. These flood plains have a history of flooding to various degrees as have all others. Outside of Grand Ledge and Lansing the population is small.

i. Reach 8-9, Lansing to Onondaga Dam. Onondaga Dam of the Jackson Complex marks the south end of this river reach. From this dam, the Grand flows northwesterly through Onondaga and Kinneyville to Eaton Rapids; here the river turns northeast and in an elongated "S" sweeps through Dimondale to Lansing. Throughout this course, the river winds through an irregular flat valley from 200 to 1,300 feet wide, into which the normal channel is incised with banks 5 to 10 feet high. Extreme flood stage is 6 to 10 feet above low water but the flooded area is not great. Swamps and woodlands make up most of the flood plain; the soils are sandy loams of moderate fertility. The neighboring countryside is woodlands and swamps, representative of the morainal areas of lower Michigan. Knobs of sand and gravel capped by clayey fill rise 20 to 50 feet above the plain. Depressions about the same distance below the plain are swampy. The flood plain area recommended for a valley preserve is shown on Plate Q-11. Portions of the flood plain would probably be inundated every year. There are numerous small communities along this reach, some of which extend into the flood plain.

5. *Tributaries as Valley Preserves (Numbers II through XIII).*

a. Prairie Creek Valley Preserve (Number II). East of Ionia a distance of 1.5 miles, is an extensive, flat flood plain of Grand River where Prairie Creek flowing from the north, joins the Grand. Proposed in the Basin Plan as another project, Reservoir Site No. 42 would be across the creek 1.5 miles north and 1/4 mile east of this confluence in Section 9, T7N, R6W, Ionia Township, Ionia County. Downstream from this proposed reservoir the creek pursues a meandering and tortuous course three river miles long to its mouth at the Grand.

The flood plain on the west bank at the creek mouth has been fashioned into a city park for a distance upstream of 0.5 mile. This is owned by the city of Ionia. Prairie Creek Dam, 0.5 mile north of the creek mouth and adjacent to Smokey Row Road, existed for many years but now is inoperative and in ruins. The dam marks the southernmost part of a narrow, steeply banked gorge which encloses a sweeping east and west meander of the creek and then both continue northward to the proposed reservoir.

Michigan State Highway 21 crosses the valley in a northeasterly direction at its midlength. Many valuable residences on spacious wooded plots are situated in the locale north of M-21 and enjoy and overlook the changing scenic setting throughout the year.

The Grand Trunk Western Railroad follows the course of the Grand River with a single track on the north bank, and bridges Prairie Creek just below the old dam site. Below the bridge on the east bank are productive farm lands; while upstream swamps and woodlands fringe the water course between the enclosing valley walls.

To better appreciate the circuitous course of the creek and the attractive relief of the preserve site, a study of the accompanying map (Plate Q-12) is necessary.

The proposed Valley Preserve extends from the Grand River, along Prairie Creek to Reservoir Site No. 42. Riding and foot trails are proposed to lead from the reservoir to the Grand River, both through and overlooking camp sites.

The creek bed in this reach is coarse, loose gravel and the water current is relatively swift. These conditions have been described as favorable for the spawning of anadromous fish. However, at this time, the preserve site does not lend itself to extensive fishing, boating or hunting.

The cemetery just east of the Prairie Creek Dam site is high enough to be out of the flood plain and would be unaffected by the preserve as planned. It is estimated that the cost to develop the preserve is $1,300,000 resulting in $62,000 as average annual costs. Average annual benefits in dollars are estimated at $5,000 for flood control, $10,000 for fish and wildlife, and $47,000 for recreation. These benefit sums amount to $62,000 with the resulting benefit/cost ratio being 1.0.

The flood plain width averages 800 feet and the slope of the creek is nine feet per mile in the area of concern. Other roads crossing the valley in this reach are, in an east-west direction, Smokey Row Road and Hillcrest Road; in a north-south direction, Prairie Road leads from M-21 northward. A detailed plan of Prairie Creek Valley Preserve is shown on Plate Q-12.

b. Maple River Valley Preserve (Number III). This proposed Valley Preserve project would extend from the city of Muir upstream along the Maple River approximately nine miles to the Ionia-Clinton County Line. Here it would join the Maple River State Game Area and should make a very desirable addition to public lands in the Maple River Valley. At this location (the Maple River at the Ionia-Clinton County Line) Fish Creek, flowing from the north, joins the Maple River. The Valley Preserve is proposed to extend, northward from this confluence, seven miles along Fish Creek to the site of the proposed Fish Creek Dam.

Excellent access to the preserve would be provided by State Highway M-21 which extends from Flint west to Grand Rapids. The Lansing metropolitan population would be especially well served by this preserve as would Grand Rapids, though possibly in a lesser way.

In this river reach, the Maple has a broad flood plain which is sparsely populated. The plain is forested with low grade hardwoods and brush. Floods occur yearly and low areas retain the accumulated water for extended periods of time. This latter encourages wildlife and sustains the existing dense overgrowth of vegetation. The flood plain is cultivated for agriculture to a very limited extent which is directed by the rate of the floodwater run-off.

The seven mile reach of Fish Creek which is proposed as part of the preserve has a greater slope than the Maple River. The valley floor is narrower and the adjoining uplands are more irregular and rolling than the comparable physical features of the Maple River. The yearly flooding of the Maple affects this part of Fish Creek, but the waters recede more rapidly because of the greater slope.

The soils in both valleys are heavy black muck and poorly drained. The adjoining uplands are sandy, well drained and in no way productive at this time, for a distance of 1/2 to 1 mile landward of the escarpments. Beyond these infertile bands, the land levels and gains fertility, and very productive agriculture exists.

The proposed preserve would offer recreational environment. Flood water effects would be reduced in a minor way. Waterfowl and fur bearing animals would benefit greatly by the creation of the additional ponds of 100 acres or less in the flood plain area, remote from the main stream channels. Fishing on the Maple River would be improved by the improvement and preservation of banks and stream bed. The preserve concept would act to benefit game in the uplands.

Trails for hiking and horseback riding are proposed to provide major recreation. Camping, picnicking and boating could also be enjoyed.

It is estimated that the cost to develop the preserve is $1,000,000 resulting in an average annual cost of $45,000. The average annual benefits are estimated to be: For flood control, $5,000; for fish and wildlife, $5,000; and for recreation, $35,000. These amounts total $45,000 and result in a benefit/cost ratio of 1.0.

A detailed plan of the preserve is shown on Plate C-13.

c. Crockery Creek Valley Preserve (Number IV). From the proposed dam at Reservoir Site 16 (Ravenna No. 2) on North Branch Crockery Creek at the east Ravenna Village limits, this stream flows .5 mile to itsconfluence with Crockery Creek. Continuing, the latter winds its way southwesterly through an unpopulated part of the village of Ravenna. The banks of these streams at these locations are 20 to 30 feet high; they slope up, gently, 60 feet to the surrounding hills. The neighboring countryside is undulatory, hilly, some contains woodlands and grass lands, and is sparsely populated. The recommended outline of this Valley Preserve is shown on Plate C-14. Soils in this proposed preserve are deep sands with low fertility and low water retention.

d. <u>Sand Creek Valley Preserve (Number V)</u>. The proposed dam for Site 74 (Sand Creek Reservoir) would be situated 3/4 mile south of the State Highway M-45 bridge over Sand Creek. From here Sand Creek flows in a very tortuous course southwest to its confluence with the Grand River. The many meanders that work this reach wind back and forth between banks 10 to 50 feet high. Between banks the flood plain varies from 500 to 1,000 feet wide. Along its axis the reach is three miles long. The flood plain is flat; woodlands extend almost its entire length. The soils are deep and durable loam, clay loam, and silty clay loam. On Plate Q-15 is outlined the recommended Valley Preserve. It is probable that parts of this flood plain are inundated yearly; the population, however, is sparse.

e. <u>Buck Creek Valley Preserve (Number VI)</u>. Buck Creek has its source in Section 9, Gaines Township, Kent County about 11 miles south of Grand Rapids. From here it flows three miles west then turns in a wide circular arc to Grandville. The water flows rather fast because the fall is 10 feet per mile. For the most part the banks have a gradual slope. The neighboring uplands are hilly and undulating, rising to some 50 feet above the stream. Adjacent to the stream the soils are deep sands and sandy loams, of low fertility. The flood plain recommended for a Valley Preserve is some 10 miles long above the creek mouth and is outlined on Plate Q-16. The population varies from dense at Grandville to sparse further upstream.

f. <u>Plaster Creek Valley Preserve (Number VII)</u>. Plaster Creek has its source in Section 23, Gaines Township, Kent County, about 14 miles south of Grand Rapids. From here it flows in a very twisting irregular course northwest skirting Grand Rapids and joining the Grand at Wyoming. Its flow is swift: it falls 13 feet per mile. The surrounding countryside is hilly and undulatory; the hills rising 50 to 100 feet above the stream. For the most part the stream banks rise on a gradual slope. Information on the extent of the flood plain is lacking; the flanking areas are flat and featureless. The soils are deep sands of low fertility. The recommended Valley Preserve is 5 miles long, along its axis; the outline is on Plate Q-16. Most of it is in an area of dense population.

g. Rogue River Valley Preserve (Number VIII). The part of the Rogue River under consideration here is that part extending south of the Rogue River State Game Area to its confluence with the Grand River at river mile 51. From Section 26, T10N, R12W, Tyrone Township, Kent County, at the south end of the Rogue River State Game Area, the Rogue River flows south to one mile past the Village of Sparta; then the stream sweeps first south, then north, then south again in a wide meander to Rockford. From Rockford, the river flows in a generally southwesterly course to its confluence with the Grand River. The proposed Rogue River Recreation Area would extend from the U.S. Highway 131 bridge 2 1/2 miles north of Rockford to 1 mile north of Sparta. A Valley Preserve is recommended from this point north to the south limits of the Rogue River State Game Area. This is flat swampy country, almost all the way. The Valley Preserve would be 1/2 mile wide and 4 1/2 miles long, with the stream meandering through the center. On gentle slopes, the countryside rises to undulatory hills 70 feet above the river. This would be the north part of the Valley Preserve. From the bridge, 2-1/2 miles north and 1-1/2 miles west of Rockford, the Rogue flows south and east through Rockford, then southwest to its confluence with the Grand River. The current is rather fast in this reach: the stream bed falls 10 feet per mile. The soil is sand and sandy loam of moderate to low fertility in this locale. North of Rockford the land is flat along the river; in the reach from Rockford southwest three miles long, the banks rise sharply 70 feet to the neighboring hills. Flat lands flank the river from here to the Grand. The river channel is sharply defined through this part. The flood plain is narrow; along the axis of the stream it is 1-1/2 miles long. This constitutes the lower part of the Valley Preserve. Taken together the upper and lower parts form Valley Preserve VIII (Rogue River), outlined on Plate Q-17. Outside of Plainfield Township, Rockford, and Sparta, the land is thinly populated.

h. Thornapple River Valley Preserve (Number IX). The Thornapple River is the longest tributary, 76 river miles, in the Basin. Under consideration in this part of the study is the river's reach from Nashville, at the Barry-Eaton County Line to its confluence with the Grand River at Ada. From Nashville, the Thornapple flows west by north to the upstream limit of the proposed reservoir at Site 22 (Labarge) at the south section line of Section 33, T4N, R10W, Irving Township, Barry County. This reach is through hilly undulatory countryside; the primary banks of the well-defined channel are 10 to 20 feet high. Many creeks and minor streams discharge into its entire length. The flood plain is narrow and of sandy loam of moderate fertility. Thornapple Lake, a lake of important size, is in the flood plain. This reach is recommended for a Valley Preserve; its length along the axis of the preserve is some 23 miles. Plate Q-18 shows the outline of the flood plain. The Valley Preserve would follow its outline as closely as property lines lend themselves to it.

The flood control reservoir at Site 22 (Labarge) would extend from this part of the Valley Preserve downstream to the dam, one quarter mile north of Labarge. From this dam the Thornapple flows due north to its confluence with the Grand River. This part is also through hilly undulatory countryside; the primary banks of the channel vary from 10 to 20 feet in height, the flood plain is flat and varies from 400 to 1,000 feet in width. As is typical in this basin, numerous creeks discharge into the Thornapple from both sides. Flood plain soils are deep sands of low fertility and poor water retention. This reach, which is about 31 miles long, is also recommended as a Valley Preserve. It is outlined on Plate Q-58. Together with the upper reach, these two constitute Valley Preserve IX. There are several communities of varying size and scattered population along this reach, of which some are in the flood plain. Valley Preserve IX is presented on Plate Q-18.

i. Flat River Valley Preserve (Number X). The Flat River is one of the more important tributaries of the Grand River, and has three

state game areas along its course. The part of the river under consideration extends from the southern boundary of the Langston State Game Area in Pine Township at Montcalm County to the confluence with the Grand River, mile 70.2, at Lowell. From the Pine-Montcalm Township Line in Montcalm County, 1-1/2 miles southwest of Langston, the Flat River flows in a wide meander to the west and back, 10 miles south through Greenville to the Flat River State Game Area. Emerging from the latter, the river continues southwest in a meandering course through Belding, skirting the Lowell State Game Area, and through Lowell to the Grand River. Several minor creeks flow into the stream along the way. It is recommended that this reach, excluding the Flat River State Game Area, be a Valley Preserve. Considering the property lines, it appears that the two parts above and below the game area would total about 15 miles in length. Topographical surveys of this area have not been made. The area, outside of Lowell, is thinly populated. The outline of the Valley Preserve is on Plate Q-19.

j. Lookingglass River Valley Preserve (Number XI). The part of the Lookingglass River under consideration here lies wholly in Clinton County. From Laingsburg at the Clinton-Shiawassee County Line, the Lookingglass flows in an irregular path, 20 miles west and 4-1/2 miles south, to a point 2 miles east and 1/2 mile north of Eagle. This is the eastern extremity of Reservoir Site 51 (Portland). Many creeks drain into the river on both sides. From Laingsburg, the river flows west through a marsh 6 miles wide and the adjacent lands then become hilly with moderate relief; the surrounding hills are some 50 feet above the stream and have gentle slopes. At the upper part of the reach the flood plain broadens at the marsh to five miles wide, then constricts to 500 to 800 feet in width through hilly countryside. Loam, sandy loam, and silty loam constitute the flood plain soils. Few people have settled here outside the communities of Wacousta and DeWitt. The outline of the flood plain and Valley Preserve is shown on Plate Q-20.

k. Red Cedar River Valley Preserve (Number XII). This river is a major tributary of the Grand River. Downstream from Reservoir Site 2 (the Red Cedar Complex) the Red Cedar River meanders to the north, then to the south, then reversing its course sweeps north again to its confluence with the Grand River in the southern part of Lansing. This reach is recommended for a Valley Preserve. Several creeks drain into the Red Cedar River from both sides. The country through which it flows is undulatory, with gentle slopes; hills rise 50 feet on either side with intermittent swamps intervening. The broad flood plain here has commercial and institutional development and is thickly populated. The proposed Valley Preserve is outlined on Plate Q-21.

l. Sycamore Creek Valley Preserve (Number XIII). Sycamore Creek originates in Section 20 of Vevay Township, Ingham County. From here, at elevation 900 feet, it winds a meandering course northwest through Mason to its confluence with the Red Cedar River southwest of Lansing. The countryside rises from the creek on gentle slopes to surrounding hills as much as 100 feet high. Many creeks originate in these hills and flow into Sycamore Creek on both sides throughout its course. Marshes exist throughout the flood plain of the creek. The flood plain is extensive and irregular with a sizeable arm extending along Mud Creek. It is recommended that this flood plain be a preserve for fish and wildlife - somewhat more limited in use than the entire concept of a Valley Preserve. The proposed Valley Preserve is outlined on Plate Q-22.

6. Summary of Suggested Watershed Protection and Flood Prevention (PL-566) Programs.

a. Introduction. This program provides a project-type approach to soil and water resource development, use, and conservation. Proper land treatment is the basic element of watershed projects, and is considered as the initial increment in project formulation. Structural measures operate in conjunction with land treatment measures to achieve project objectives.

This study has identified 14 watersheds with potential for development within the next 10 to 15 years (Table III-5, Table III-6, and Plate Q-1). These watersheds may be developed if sponsored by qualified local groups. The evaluation of these watersheds was based on the maximum potential development. The scope and purpose of these projects will be dependent upon the desires of the local sponsoring organizations.

Investigations also identified 28 watersheds with potential for future development (Table III-7, Table III-8, and Plate Q-1). These would be justified primarily through bringing new land into agricultural production, and may become feasible with a growing demand for food and fiber in the future.

b. Nonstructural Improvements. A program of nonstructural improvements is essential to the proper functioning of a watershed project. Land treatment measures will reduce surface water runoff, erosion, and sedimentation which would adversely affect the construction, operation and maintenance of the proposed structural works of improvement.

These measures would be applied through an accelerated program of assistance to watershed landowners. This technical assistance would be provided through soil conservation districts by the Soil Conservation Service and the Michigan Department of Natural Resources in cooperation with the Forest Service. This accelerated program would be in addition to conservation programs available under other authorities.

The land treatment measures would be installed by the land owners. The estimated costs are total installation costs and do not reflect cost-sharing assistance which might be available through other programs. The cost of technical assistance in the 14 potential watershed areas proposed for early action is estimated to be $800,000 for the Soil Conservation Service and $191,700 for the Forest Service (Table III-9).

The proper treatment of cropland and pasture land in watershed projects would help control erosion and eliminate unfavorable soil conditions.

Cropland treatment would involve: (1) water control measures, such as terraces, waterways, and field diversions, (2) measures to protect the soil from erosion and to increase infiltration rates, such as strip

TABLE III- 5 SUMMARY OF UPSTREAM AREAS WITH POTENTIAL FOR EARLY DEVELOPMENT (10-15 YEARS) - PHYSICAL DATA

Grand River Basin, Michigan

Watershed Name	Watershed Area (sq.mi.)	Flood 1/ Plain Area (Acres)	Flooding and Inadequate Drainage Area: Mineral Soil (Acres)	Flooding and Inadequate Drainage Area: Organic Soil (Acres)	Channel Improvement (Miles)	Structure Site (Number)
Twin Lakes Drain	5.4	--	265	797	5.4	
Freeman Marsh Drain	8.0	--	--	1,223	7.2	
Huntoon Lake	11.6	--	511	696	6.4	
Perry Creek	10.4	--	1,536	1,715	5.3	
Bly Lake	11.7	--	1,302	1,367	8.8	
Eaton Rapids	13.6	--	1,321	492	8.3	
Upper Columbia Creek	18.3	--	1,527	1,019	7.6	
Portage River	185.8	7,100	3,420	4,940	21.5	171 5/
Prairie Creek	46.0	--	2,386	615	8.4	
Libhart Creek	17.1	--	1,039	637	8.4	
Upper Maple River 2/	312.0	16,500	24,470	4,390	54.2 3/	109 and 110 4/
Hayworth Creek	93.5	--	2,432	1,950	14.0	
Stony Creek	178.1	2,227	7,221	1,024	42.1	
Rogue River	37.9	3,100	--	3,100	10.6	
TOTAL	949.9	28,927	47,430	23,965	208.2	

1/ This area is also included in flooding and inadequate drainage area.
2/ Data from PL-566 Watershed Work Plan, both East and West, July 1969.
3/ In addition to channel improvement, there are two multiple-purpose structures, 14.4 miles of dike construction, and four drainage pumping stations.
4/ Multiple-purpose structures - flood prevention and recreation.
5/ Single-purpose fish and wildlife structure.

TABLE III-6 · SUMMARY OF UPSTREAM AREAS WITH POTENTIAL FOR EARLY DEVELOPMENT (10-15 YEARS) - ECONOMIC DATA

Grand River Basin, Michigan

Watershed Name	Average Annual Benefits 1/ — Flood Prevention: Flood Damage Reduction	Average Annual Benefits 1/ — Flood Prevention: More Intensive Land Use	Average Annual Benefits 1/ — Drainage	Average Annual Benefits 1/ — Recreation	Average Annual Benefits 1/ — Total	Total 2/ Installation Cost	Average 3/ Annual Installation Cost	Benefit Cost Ratio
Twin Lakes Drain	--	3,100	3,101	--	6,201	90,700	5,672	1.09:1
Freeman Marsh Drain	--	4,042	4,042	--	8,084	120,000	7,486	1.08:1
Huntoon Lake	--	4,292	4,293	--	8,585	110,600	6,861	1.25:1
Perry Creek	--	5,000	5,000	--	10,000	105,300	6,537	1.53:1
Bly Lake	--	5,889	5,889	--	11,778	148,700	9,238	1.27:1
Eaton Rapids	--	5,032	5,033	--	10,065	140,900	8,759	1.15:1
Upper Columbia Creek	--	5,869	5,870	--	11,739	119,300	7,669	1.53:1
Portage River	143,941	--	93,869	10,000 6/	247,810	3,892,250 7/	228,832	1.08:1
Prairie Creek	--	8,100	8,101	--	16,201	230,500	14,482	1.12:1
Libhart Creek	--	5,162	5,163	--	10,325	128,100	8,342	1.24:1
Upper Maple River 4/	184,100	115,600	115,600	1,495,600	2,190,700 5/	11,287,400	817,059	2.70:1
Hayworth Creek	--	25,575	25,575	--	51,150	531,700	32,290	1.58:1
Stony Creek	9,496	27,009	27,009	--	63,514	801,200	53,510	1.19:1
Rogue River	--	38,750	38,750	--	77,500	1,075,650	60,348	1.28:1
Total	337,537	253,420	347,295	1,505,600	2,723,652	18,782,300	1,267,085	2.15:1

1/ Price base - adjusted normalized prices.
2/ Price base - 1967
3/ Amortized at 4 7/8 percent interest over a 50-year period, includes O&M cost.
4/ Data from Watershed Work Plan, both East and West - July 1969.
5/ Includes $279,800 for local secondary benefits.
6/ Fish and wildlife benefits.
7/ Includes $155,900 installation cost for structure No. 171 (fish and wildlife).

TABLE III-7 SUMMARY OF UPSTREAM AREAS WITH POTENTIAL FOR FUTURE DEVELOPMENT - PHYSICAL DATA

Grand River Basin, Michigan

	Watershed Area (sq. mi.)	Flood Plain Area 1/ (acres)	Flooding and Inadequate Drainage Area: Mineral Soil (acres)	Flooding and Inadequate Drainage Area: Organic Soil (acres)	Channel Improvement (miles)
Snyder & Wheeler Drain	9.2	-	471	920	10.7
Rives Junction	8.0	-	307	653	5.3
State	4.0	-	128	32	1.4
Berry Lake	2.7	-	-	242	1.1
Pleasant Lake	5.3	-	-	544	4.3
Whitney Drain	3.8	-	400	-	4.2
Leslie	7.5	-	511	696	6.4
Darling Christie Drain	4.5	-	288	154	2.6
Lanes Lake	4.7	-	256	-	2.0
Willow Creek	16.6	-	510	1,892	12.1
Sandstone Creek	31.6	-	1,059	2,709	23.1
Tompkins	6.8	-	416	205	5.4
Spring Brook	35.3	-	662	2,326	23.3
Bateese Creek	18.0	-	390	1,570	5.3
Upper Cedar River	20.1	-	610	3,460	17.6
Winegar	5.7	-	171	968	4.9
Middle Cedar River	28.7	93	859	4,862	37.6
Randal	3.4	63	242	730	4.5
Grant	4.8	88	344	1,040	3.0
Brown	4.8	88	344	1,040	5.7
Mud Creek	28.3	-	1,830	986	18.1
Lookingglass River	187.0	-	5,188	10,617	75.0
Pewamo	7.5	-	1,035	55	6.9
Penny Creek	18.9	-	1,041	1,000	7.3
Hemmingway Lake	2.2	-	110	82	1.0
Black Creek (Montcalm & Kent)	45.6	-	3,968	3,968	14.2
SUBTOTAL	515.0	332	21,140	40,751	303.0
Buck Creek	51.2	2/	2/	2/	2/
Plaster Creek	60.4	2/	2/	2/	2/
TOTAL	626.6	2/	2/	2/	2/

1/ This area is also included in flooding and inadequate drainage area.
2/ Detailed data not available at this time.

TABLE III-8 SUMMARY OF UPSTREAM AREAS WITH POTENTIAL FOR FUTURE DEVELOPMENT - ECONOMIC DATA

Grand River Basin, Michigan
(Dollars)

Watershed Name	Average Annual Benefits 3/ More Intensive Land Use 2/	Changed Land Use	Total	Total Installation Cost 4/	Average Annual Installation Cost 5/
Snyder & Wheeler Drain	1,422	11,105	12,527	180,400	11,150
Rives Junction	732	6,745	7,477	90,100	5,580
State	240	1,760	2,000	24,400	1,511
Berry Lake	-	2,400	2,400	19,500	1,208
Pleasant Lake	96	6,280	6,376	77,900	4,925
Whitney Drain	1,800	3,100	4,900	70,900	4,399
Leslie	3,212	4,212	7,424	110,600	6,861
Darling Christie Drain	1,446	1,840	3,286	44,900	2,782
Lanes Lake	120	2,775	2,895	35,100	2,176
Willow Creek	4,884	20,975	25,859	207,600	13,132
Sandstone Creek	4,728	35,415	40,143	486,100	30,543
Tompkins	600	6,095	6,695	91,700	5,696
Spring Brook	2,130	34,780	36,910	468,700	29,189
Bateese Creek	3,660	9,250	12,910	104,700	6,774
Upper Cedar River	17,360	53,450	70,810	378,000	24,096
Winegar	4,889	8,579	13,468	79,800	3,432
Middle Cedar River	24,561	163,001	187,562	988,550	62,385
Randal	5,782	14,112	19,894	78,000	4,840
Grant	8,229	20,084	28,313	52,000	3,232
Brown	8,229	20,084	28,313	97,500	6,048
Mud Creek	15,555	24,650	40,205	415,700	25,511
Lookingglass River 1/	16,405	574,297	590,702	1,169,200	76,850
Pewamo	4,350	4,120	8,470	118,200	7,440
Penny Creek	833	15,150	15,983	61,000	4,557
Hemmingway Lake	243	1,980	2,223	17,200	1,064
Black Creek (Montcalm & Kent)	2,925	44,595	47,520	312,400	19,622
TOTAL	134,431	1,090,834	1,225,265	5,780,150	365,003

1/ Data from major and local drainage report, SCS-June 1961
2/ Composed of Agricultural water management (Drainage) benefits and floodwater damage reduction benefits that have not been separated. 3/ Price Base - Adjusted normalized prices. 4/ Price Base - 1967.
5/ Amortized at 4 7/8 percent interest over a 50-year period, includes O & M cost.

TABLE III-9 COST OF ACCELERATED LAND TREATMENT PROGRAM FOR FOURTEEN UPSTREAM AREAS WITH POTENTIAL FOR DEVELOPMENT BY 1985

Grand River Basin, Michigan

Watershed	Watershed Area	Land Treatment Installation Cost 1/				
		Cropland	Pasture	Forest	Misc.	Total
	(Acres)	(Dollars)				
Twin Lakes	3,456	38,100	7,500	2,100	1,900	49,600
Freeman-Marsh	5,120	56,400	11,000	1,900	2,900	72,200
Huntoon Lake	7,424	81,800	16,000	700	4,200	102,700
Perry Creek	6,656	73,400	14,000	3,400	3,700	94,500
Bly Lake	7,488	82,500	16,200	2,800	4,200	105,700
Eaton Rapids	8,704	95,900	18,800	3,500	4,900	123,100
Upper Columbia	11,712	129,000	25,000	7,000	6,600	167,900
Portage River	118,912	1,408,100	156,000	61,500	66,900	1,692,500
Prairie Creek	29,440	324,400	63,500	20,800	16,600	425,300
Libhart Creek	10,944	124,200	23,600	5,400	6,200	159,400
Upper Maple	195,460	1,342,800	107,900	17,500	20,100	1,488,300
Hayworth Creek	59,840	266,900	31,500	2,600	9,700	310,700
Stony Creek	113,984	1,373,500	145,900	36,100	64,200	1,609,700
Rogue River	24,256	267,300	52,300	26,900	13,700	360,200
Subtotal	603,396	5,654,300	689,500	192,200	225,800	6,771,800
Technical Assistance						
Soil Conservation Service						800,000
Federal-State Cooperative Forestry						191,700
Total						7,763,500

1/ Price Base - 1967

cropping, contouring, cover crops, conservation cropping systems, minimum tillage, and management of crop residues; (3) farm drainage systems; (4) irrigation; (5) gully control measures; and (6) conversion of cropland to grass or trees. Within the 14 potential watersheds, 107,600 acres of cropland would be adequately treated at an estimated installation cost of $5,664,300.

Pasture land treatment measures would include pasture and hayland planting, pasture and hayland renovation, and farm drainage systems. Within the 14 potential watersheds, 20,000 acres of pasture land would be treated at an estimated installation cost of $689,500.

The treatment program on forest land would involve greater technical assistance by State and Federal agencies in assisting private land owners with the management of their land. The hydrologic condition could be improved or protected by proper planning, by using the forest land as a renewable resource, and by applying various treatment measures. These measures would include: tree planting; hydrologic stand improvement, including thinning, weeding, and sanitation cutting; protection from livestock grazing; and protection from overcutting and excessive logging. Forest fire protection would continue throughout the Basin, furnished by the Michigan Department of Natural Resources in cooperation with the United States Forest Service under the Clarke-McNary Cooperative Fire Control Program. Within the 14 potential watersheds, 12,600 acres of forest land would be adequately treated. This figure includes multiple treatment of some acres. The total accumulated area of individual measures to be applied would be 27,200 acres at an estimated installation cost of $192,000.

Treatment of miscellaneous land is needed to control erosion and reduce sedimentation. Generally this treatment will involve planting grasses and trees. Within the 14 potential early-action watersheds, 8,400 acres of miscellaneous land should be treated at an estimated cost of $225,000.

c. Structural Improvements. Normally not all watershed needs can be met solely by land treatment. Problems such as flooding and impaired drainage usually require structural measures for adequate relief. In the watershed program, waterflow control measures are planned to operate as a system in conjunction with land treatment measures.

Floodwater retardation is the primary consideration in designing a system of waterflow control measures. Channel improvement, floodways, or diversions are considered supplementary to floodwater retardation except where necessary to achieve project objectives at a reasonable cost.

The primary watershed needs in the Basin are flood control and improved agricultural drainage. These problems, as well as the general lack of adequate floodwater retention sites, require that channel improvement be utilized for waterflow control. Within the 14 potential watersheds, 208.3 miles of multi-purpose (flood prevention and drainage) channel improvement are proposed (Table III-8).

In addition, two multi-purpose structures are proposed in the Upper Maple River Watershed. These structures will operate in conjunction with channel improvement to reduce flooding, and will also provide surface water area for recreational use.

Structure 109, with a recreation pool of 235 surface acres, would be managed for extensive use with fishing as the major activity. Peak daily use is expected to be 3,200 visitors. Structure 110 would have a recreation pool of 412 surface acres. The primary activities would be swimming, picnicking, camping, boating, hiking, active games, and nature study. Peak daily use is estimated to be 20,500 visitors. These developments, located in the Lansing Subarea, would fill a need for water-related outdoor recreation facilities in the area of greatest demand.

The installation cost of these proposed structural measures within the 14 potential watersheds is estimated to be $18,782,300 (Table III-9). Under provisions of the Watershed Protection and Flood Prevention Act (PL-566), qualified local sponsors would be eligible for technical assistance for the design, and cost-sharing assistance for the construction, of these structural measures.

7. Watersheds Suggested for Development by 1975.

a. Upper Columbia Creek. This watershed is a tributary to the Grand River, draining 18.3 square miles (11,012 acres) of Ingham County. The area lies in the Ingham Soil Conservation District, and has flooding and inadequate drainage on 2,546 acres (1,527 acres of mineral soil and 1,019 acres of organic soil). There are no potential floodwater retardation sites in the watershed. The works of improvement needed for the watershed include 7.6 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

b. Portage River. This watershed has a drainage area of 185.8 square miles (119,912 acres) in Ingham, Jackson, and Washtenaw Counties. The works of improvement would be within the Jackson County Soil Conservation District. Flooding and inadequate drainage are a problem on 8,360 acres (3,420 acres of mineral soil and 4,940 acres of organic soil). Flooding is the primary problem on 7,100 of the 8,360 acres. There are no potential floodwater retardation structure sites in the watershed. Channel improvement is needed on 21.5 miles of channel, except that 10.1 miles of channel improvement on the Grand River below its confluence with the Portage River would not be required if the Jackson Reservoir Complex were to be constructed. A pump station would be required, however, to provide an adequate outlet for the Portage River.

c. Upper Maple River. This watershed drains 312 square miles (199,680 acres). The watershed has already been authorized for Public Law 566 planning, and a watershed work plan was prepared in August 1969. The Soil Conservation Districts and County Drain Commissioners of Clinton, Gratiot, and Shiawassee Counties and the Maple River Inter-County Drainage Board are the sponsors. There are flooding and inadequate drainage problems on 28,860 acres (24,470 acres of mineral soil and 4,390 acres of organic soil). Flooding is the primary problem on 16,500 of the 28,860 acres. Improvements for drainage and flood control, 14.4 miles of channel improvement with levees, and four pumping stations with collection ditches are proposed. A 25.9 mile multiple purpose (flood prevention and drainage) channel extending from the upper portion of the Maple River to approximately one mile below the village of Duplain, and 13.9 miles

of multiple purpose channels on the main stem tributaries, are also proposed. Works of improvement for the main stem of the Maple River below Bannister would include 14.4 miles of channel improvements with levees to provide a floodway from Bannister to U.S. Highway 27. Four electric-driven pumping stations with collection ditches would be located in this area to pump water from adjacent areas into the floodsay. Watershed development would provide flood damage reduction, drainage, and recreation benefits. The Upper Maple River Watershed project was approved by Congress in 1971; final designs are now under preparation.

d. Hayworth Creek. This tributary to the Maple River drains 93.4 square miles (59,776 acres) of Clinton County. The area lies in the Clinton County Soil Conservation District, and has flooding and inadequate drainage on 4,382 acres (2,432 acres of mineral soil and 1,950 acres of organic soil). The flat topography of the upper portions of the watershed eliminates the possibility of using upstream structures for floodwater retardation. Works of improvement needed for the watershed consist of 14.0 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage.

e. Stony Creek. This watershed drains 178.1 square miles (113,984 acres) of Clinton and Ionia Counties. The area is primarily in the Clinton County Soil Conservation District. There are flooding and inadequate drainage problems on 8,245 acres (7,221 acres of mineral soil and 1,024 acres of organic soil). Flooding is the primary problem on 2,227 acres.

f. Rogue River. This watershed drains 37.9 square miles (24,756 acres) of Newaygo and Kent Counties, and has inadequate drainage and flooding on 3,100 acres of fertile organic soil. Due to the flat topography of the watershed, there is no possibility of using structures for floodwater retardation. High-valued vegetable crops such as onions, red beets, and carrots are grown. Channel improvement is needed on 10.6 miles of channel. Works of improvement are needed primarily within the Newaygo Soil Conservation District.

8. <u>Watersheds Suggested for Development by 1980</u>.

a. <u>Twin Lakes Drain</u>. This tributary of the Grand River drains 5.4 square miles (3,456 acres) of Jackson County. The area lies in the Jackson County Soil Conservation District and has flooding and inadequate drainage on 1,062 acres (265 acres of mineral soil and 797 acres of organic soil). There is no possibility of using a floodwater retarding structure to prevent flooding in this watershed. The watershed needs 5.3 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

Impoundment structure site No. 130 at the lower end of the watershed would have potential for fish and wildlife and for recreation. Installation of this structure would inundate portions of the proposed channel improvement in the Twin Lakes Drain watershed.

b. <u>Freeman Marsh Drain</u>. This watershed drains 8.0 square miles (5,120 acres) of Ingham and Jackson Counties, and has flooding and inadequate drainage on 1,223 acres of organic soil. The topography of the watershed precludes the use of structures for floodwater retardation. The watershed needs 7.2 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits. The works of improvement are needed primarily within the Ingham Soil Conservation District.

c. <u>Huntoon Lake</u>. This watershed includes tributaries of Huntoon Creek (a tributary of the Grand River) and drains 11.6 square miles (7,424 acres) of Ingham and Jackson Counties. The area lies primarily in the Ingham Soil Conservation District and has flooding and inadequate drainage on 1,207 acres (511 acres of mineral soil and 696 acres of organic soil). There is no possibility of using a floodwater retarding structure in this watershed.

d. <u>Perry Creek</u>. This watershed has a drainage area of 10.4 square miles (6,656 acres) in Ingham County. The area lies in the Ingham Soil Conservation District. It has flooding and inadequate drainage on 3,251 acres (1,536 acres of mineral soil and 1,715 acres of organic soil). The flat topography of the watershed precludes the use of floodwater retarding structures for flood prevention. The watershed needs

5.3 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

e. Bly Lake. This watershed has a drainage area of 11.7 square miles (7,488 acres) in Eaton County. The channel in this watershed is a tributary of Spring Brook which, in turn, is a tributary of the Grand River. The area lies in the Thornapple-Grand Soil Conservation District, and has flooding and inadequate drainage on 2,669 acres (1,302 acres of mineral soil and 1,367 acres of organic soil). The topography of the watershed precludes the use of structures for floodwater retardation. The watershed needs 8.8 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

f. Eaton Rapids. This watershed includes two small tributaries to the Grand River in Eaton County having a drainage area of 13.6 square miles (8,704 acres). The area lies in the Thornapple-Grand Soil Conservation District, and has flooding and inadequate drainage on 1,813 acres (1,321 acres of mineral soil and 492 acres of organic soil). The topography of the watershed precludes the use of structures for floodwater retardation. The watershed needs 8.3 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

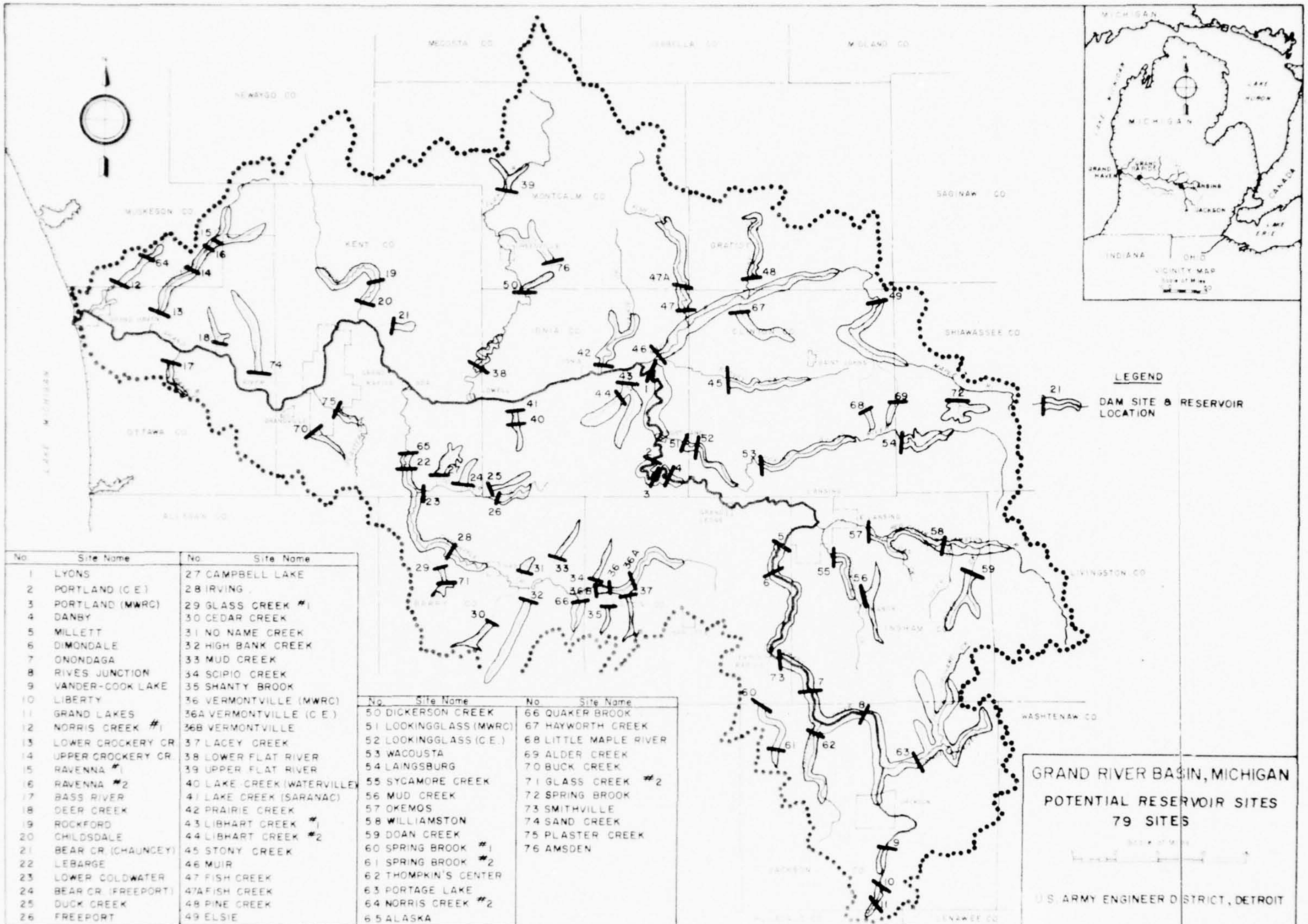
g. Prairie Creek. The area proposed for development is limited to the land drained by the upper reaches of Prairie Creek, a tributary of the Grand River. The watershed drains 46 square miles (29,440 acres) of land, mostly in Montcalm County but partly in Ionia County. The watershed has flooding and inadequate drainage on 3,001 acres (2,386 acres of mineral soil and 615 acres of organic soil). There are no potential floodwater retarding structure sites in the watershed. The watershed needs 8.4 miles of channel improvement. The works of improvement would be in the Montcalm Soil Conservation District.

h. Libhart Creek. This watershed is at the upper end of Libhart Creek, a tributary to the Grand River. The watershed drains 17.1 square miles (10,944 acres) in the Ionia County Soil Conservation District. Flooding and inadequate drainage occur on 1,676 acres (1,039 acres of

mineral soil and 637 acres of organic soil). The flat topography of the watershed eliminates the possibility of structures for floodwater retardation. Channel improvement is needed on 8.4 miles of channel. Watershed development would provide both flood damage reduction and drainage benefits.

9. Investigation of Impoundment Sites.

a. Screening of Reservoir Sites. The Corps of Engineers and the Soil Conservation Service inventoried 79 and 132 potential reservoir sites, respectively. In identifying the sites, use was made of (1) a list of dams prepared by the Michigan Department of Natural Resources; (2) a Corps of Engineers report (House Document No. 80, 73rd Congress, 1st Session) prepared under the provisions of House Document No. 308, 69th Congress, 1st Session; (3) a report by the Federal Power Commission; and (4) a Michigan Water Resources Commission report on the Upper Grand River basin. United States Geological Survey and Army Map Service data were also used for this purpose. Individual cost estimates were made for many of the sites inventoried, particularly those that appeared to have substantial engineering and economic feasibility. A water surface elevation-surface area-storage volume relationship was developed and used in connection with determining estimated costs of developing different alternative reservoir plans considered for each site. Major items of cost considered included (1) required land (fee) that would be inundated and a 300-foot strip and other land that would require easements; (2) highways, railroads and related facilities including bridges, and buildings that would be relocated or removed; (3) clearing and grubbing of proposed reservoir sites; and (4) the dam, spillway, and dikes. Preliminary cost, hydrologic, and related data concerning the potential reservoir sites inventoried by the Corps of Engineers and Soil Conservation Service are presented on pages III-48 thru III-59. A preliminary cost estimate showing all the items of cost taken into consideration for the proposed Portland Reservoir site is presented in Table III-21. Similar cost estimates were prepared for the other potential sites discussed on pages III-60 thru III-102. Plates Q-39 thru Q-64 show the locations and plans of the potential reservoir sites that would be developed as part of Plan A.



No	Site Name	No	Site Name	No	Site Name	No	Site Name
1	LYONS	27	CAMPBELL LAKE	50	DICKERSON CREEK	66	QUAKER BROOK
2	PORTLAND (C.E.)	28	IRVING	51	LOOKINGGLASS (MWRC)	67	HAYWORTH CREEK
3	PORTLAND (MWRC)	29	GLASS CREEK #1	52	LOOKINGGLASS (C.E.)	68	LITTLE MAPLE RIVER
4	DANBY	30	CEDAR CREEK	53	WACOUSTA	69	ALDER CREEK
5	MILLETT	31	NO NAME CREEK	54	LAINGSBURG	70	BUCK CREEK
6	DIMONDALE	32	HIGH BANK CREEK	55	SYCAMORE CREEK	71	GLASS CREEK #2
7	ONONDAGA	33	MUD CREEK	56	MUD CREEK	72	SPRING BROOK
8	RIVES JUNCTION	34	SCIPIO CREEK	57	OKEMOS	73	SMITHVILLE
9	VANDER-COOK LAKE	35	SHANTY BROOK	58	WILLIAMSTON	74	SAND CREEK
10	LIBERTY	36	VERMONTVILLE (MWRC)	59	DOAN CREEK	75	PLASTER CREEK
11	GRAND LAKES	36A	VERMONTVILLE (C.E.)	60	SPRING BROOK #1	76	AMSDEN
12	NORRIS CREEK #1	36B	VERMONTVILLE	61	SPRING BROOK #2		
13	LOWER CROCKERY CR	37	LACEY CREEK	62	THOMPKIN'S CENTER		
14	UPPER CROCKERY CR	38	LOWER FLAT RIVER	63	PORTAGE LAKE		
15	RAVENNA #1	39	UPPER FLAT RIVER	64	NORRIS CREEK #2		
16	RAVENNA #2	40	LAKE CREEK (WATERVILLE)	65	ALASKA		
17	BASS RIVER	41	LAKE CREEK (SARANAC)				
18	DEER CREEK	42	PRAIRIE CREEK				
19	ROCKFORD	43	LIBHART CREEK #1				
20	CHILDSDALE	44	LIBHART CREEK #2				
21	BEAR CR. (CHAUNCEY)	45	STONY CREEK				
22	LEBARGE	46	MUIR				
23	LOWER COLDWATER	47	FISH CREEK				
24	BEAR CR. (FREEPORT)	47A	FISH CREEK				
25	DUCK CREEK	48	PINE CREEK				
26	FREEPORT	49	ELSIE				

Figure III-1

Table III-10

RESERVOIR SITES INVENTORIED BY THE CORPS OF ENGINEERS

SITE NO.	SITE NAME	RIVER	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
1	Lyons	Grand	1,777	710	65	3,100	56,000	8,825,000
2	Portland (CE)	Grand	1,418	800	77	5,500	158,000	11,626,000
3	Portland (MWRD)	Grand	1,400	800	67	3,600	105,000	8,042,000
4	Danby	Grand	1,382	800	50	1,920	37,500	4,392,000
5	Millett	Grand	856	860	29	5,780	63,700	8,955,000
6	Dimondale	Grand	846	860	20	1,800	14,500	3,484,000
7	Onondaga	Grand	569	920	37	27,600	221,300	25,084,000
8	River Junction	Grand	409	920	22	19,300	109,300	13,493,000
9	Vander-Cook Lake	Grand	53	960	12	1,200	6,900	1,403,000
10	Liberty	Grand	25	1,020	26	510	4,300	833,000
11	Grand Lakes	Grand	10	1,050	31	520	7,500	599,000
12	Norris Creek #1	Grand	29	610	21	580	6,200	1,079,000
13	Lower Crockery Creek	Grand	160	620	35	2,320	27,700	2,818,000
14	Upper Crockery Creek	Grand	110	660	48	1,070	19,700	2,680,000
15	Ravenna #1	Crockery	45	680	35	320	4,800	1,056,000
16	Ravenna #2	Crockery	45	680	35	390	5,800	1,024,000
17	Bass River	Grand	41	610	25	640	6,000	1,380,000
18	Deer Creek	Grand	35	620	32	710	9,300	1,444,000
19	Rockford	Rogue	231	740	50	5,310	78,300	6,205,000
20	Childsdale	Rogue	258	700	38	320	4,500	1,710,000
21	Bear Creek (Chauncy)	Grand	27	700	64	720	16,400	2,884,000
22	Labarge	Thornapple	798	740	61	7,000	115,000	8,777,000
23	Lower Coldwater	Thornapple	192	760	50	3,370	68,400	4,476,000
24	Bear Creek (Freeport)	Thornapple	50	780	36	870	10,500	2,139,000
25	Duck Creek	Thornapple	26	820	50	940	19,500	2,961,000
26	Freeport	Thornapple	80	800	40	2,180	24,200	2,599,000
27	Campbell Lake	Thornapple	10	800	50	2,460	39,900	3,214,000
28	Irving	Thornapple	525	760	23	550	5,700	2,676,000

Table III-10 (Cont'd)

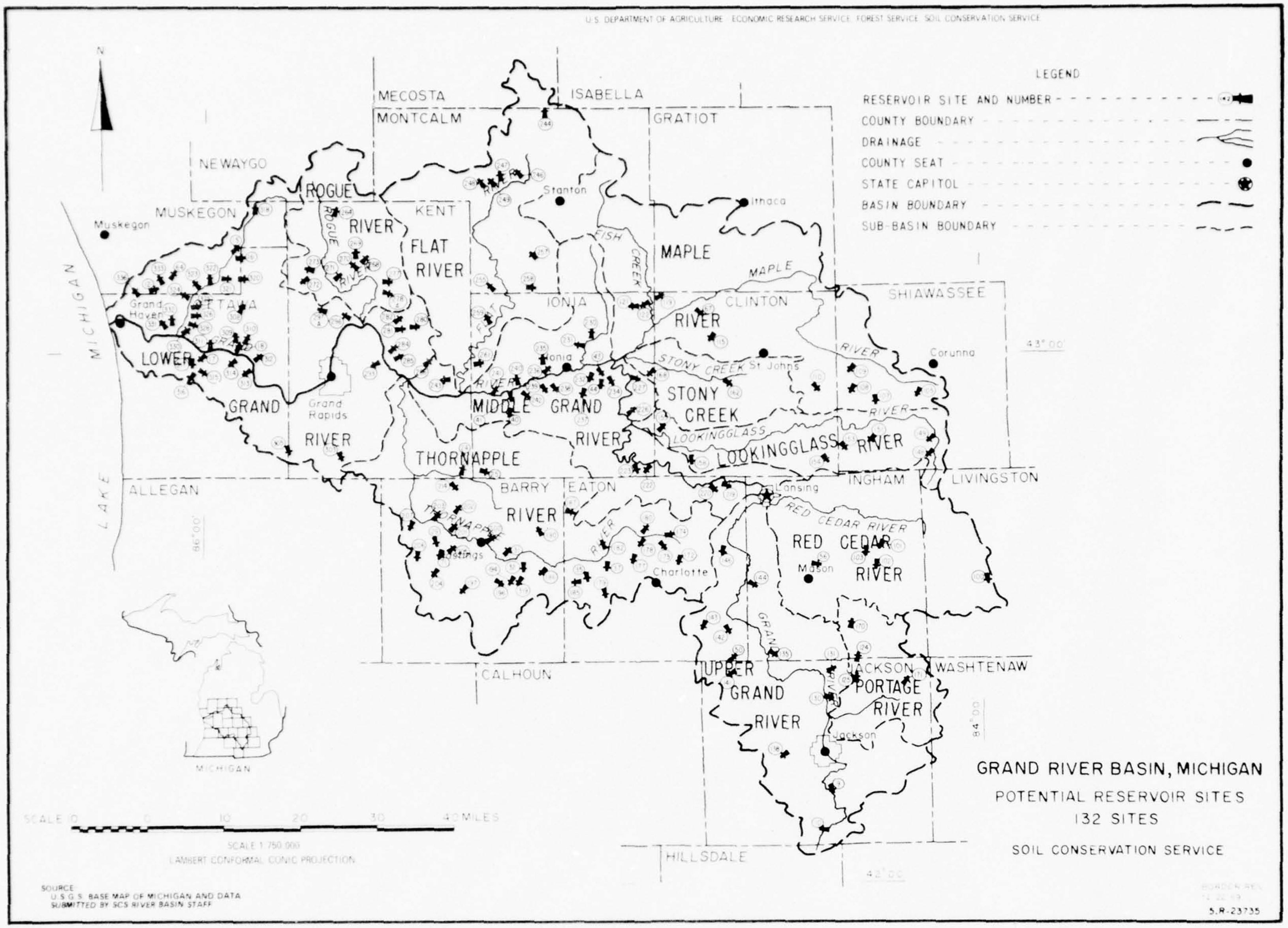
RESERVOIR SITES INVENTORIED BY THE CORPS OF ENGINEERS (CONTINUED)

SITE NO.	SITE NAME	RIVER	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
29	Glass Creek	Thornapple	31	820	39	1,060	15,100	1,437,000
30	Cedar Creek	Thornapple	44	900	79	3,460	109,700	3,509,000
31	No Name Creek	Thornapple	6	900	61	730	13,600	2,225,000
32	High Bank Creek	Thornapple	32	920	85	3,480	46,300	5,249,000
33	Mud Creek	Thornapple	53	820	24	1,260	15,700	1,870,000
34	Scipio Creek	Thornapple	10	840	20	1,060	10,600	1,108,000
35	Shanty Brook	Thornapple	13	860	42	570	11,600	1,800,000
36	Vermontville (MWRC)	Thornapple	190	840	28	4,600	42,500	5,802,000
36A	Vermontville (CE)	Thornapple	161	840	23	2,790	20,900	3,297,000
36B	Vermontville	Thornapple	190	840	28	7,350	87,600	8,819,000
37	Lacey Creek	Thornapple	24	860	39	1,710	23,300	3,205,000
38	Lower Flat River	Flat	578	750	66	2,020	51,600	4,863,000
39	Upper Flat River	Flat	50	850	10	1,920	9,600	2,198,000
40	Lake Creek (Waterville)	Grand	23	760	98	590	20,000	4,089,000
41	Lake Creek (Saranac)	Grand	28	720	68	430	9,140	1,607,000
42	Prairie Creek	Grand	100	750	100	1,820	61,900	6,800,000
43	Libhart Creek #1	Grand	53	750	80	980	19,300	4,422,000
44	Libhart Creek #2	Grand	25	760	62	430	9,200	2,012,000
45	Stony Creek	Maple	139	730	30	4,890	48,950	4,654,000
46	Muir	Maple	766	650	16	11,220	89,000	11,121,000
47	Fish Creek	Maple	161	700	65	1,220	35,600	6,114,000
47A	Fish Creek	Maple	141	750	60	2,870	97,000	5,130,000
48	Fish Creek	Maple	82	725	70	2,170	47,490	4,486,000
49	Elsie	Maple	205	720	35	8,210	61,000	7,464,000
50	Dickerson Creek	Flat	101	800	30	990	14,900	1,622,000
51	Portland (MWRD)	Lookingglass	312	760	48	3,230	36,700	3,861,000
52	Portland (CE)	Lookingglass	310	770	46	3,350	35,970	3,717,000

Table III-10 (Cont'd)

RESERVOIR SITES INVENTORIED BY THE CORPS OF ENGINEERS (CONTINUED)

SITE NO.	SITE NAME	RIVER	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
53	Wacousta	Lookingglass	262	800	19	1,330	10,910	2,283,000
54	Laingsburg	Lookingglass	161	820	13	2,110	11,500	3,339,000
55	Sycamore Creek	Red Cedar	102	860	22	1,300	14,000	2,124,000
56	Mud Creek	Red Cedar	32	880	10	3,160	31,650	2,776,000
57	Okemos	Red Cedar	306	860	29	2,040	23,800	4,394,000
58	Williamston	Red Cedar	228	880	24	6,610	67,200	10,221,000
59	Doan Creek	Red Cedar	33	900	30	2,610	38,900	3,004,000
60	Spring Brook #1	Grand	35	930	14	2,220	12,320	20,430,000
61	Spring Brook #2	Grand	18	950	23	2,200	19,100	2,309,000
62	Sandstone Creek	Grand	89	950	49	7,460	115,120	6,858,000
63	Portage Lake	Portage	159	920	10	10,440	20,880	6,695,000
64	Norris Creek #2	Grand	14	640	32	430	4,610	800,000
65	Alaska	Thornapple	803	720	52	2,690	41,400	5,372,000
66	Quaker Brook	Thornapple	17	840	21	660	7,240	1,979,000
67	Hayworth	Maple	50	700	45	920	14,300	1,401,000
68	Little Maple River	Maple	12	800	37	1,530	18,000	2,006,000
69	Alder Creek	Maple	6	800	42	910	14,200	1,507,000
70	Buck Creek	Grand	44	660	28	560	5,940	1,482,000
71	Glass Creek #2	Thornapple	31	840	46	1,610	29,720	1,839,000
72	Spring Brook	Maple	9	800	42	1,020	14,400	2,495,000
73	Smithville	Grand	652	900	29	3,900	44,000	7,357,000
74	Sand Creek	Grand	41	660	62	1,470	29,600	4,107,000
75	Plaster Creek	Grand	44	720	60	2,750	64,600	7,647,000
76	Amsden	Flat	96	800	35	1,090	19,000	2,316,000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RESERVOIR SITE AND NUMBER
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COUNTY SEAT
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ISABELLA
MONTCALM
GRATIOT
NEWAYGO
MUSKEGON
Muskegon
KENT
ROGUE
RIVER
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Stanton
Ithaca
MAPLE
FISH
CREEK
SHIAWASSEE
CLINTON
IONIA
Ionia
St Johns
Corunna
OTTAWA
Grand Haven
LOWER
GRAND
Grand Rapids
RIVER
MIDDLE
GRAND
RIVER
STONY CREEK
STONY
CREEK
LOOKINGGLASS
LOOKINGGLASS
RIVER
THORNAPPLE
RIVER
LAKE
MICHIGAN
ALLEGAN
BARRY
EATON
Hastings
Charlotte
INGHAM
LIVINGSTON
Lansing
RED CEDAR RIVER
RED CEDAR
RIVER
Mason
CALHOUN
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SUBMITTED BY SCS RIVER BASIN STAFF
GRAND RIVER BASIN, MICHIGAN
POTENTIAL RESERVOIR SITES
132 SITES
SOIL CONSERVATION SERVICE
5,R-23735

Figure III-2

Table III-11

RESERVOIR SITES INVENTORIED BY THE SOIL CONSERVATION SERVICE

SITE NO.	STREAM	SUB-BASIN	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
100	Red Cedar	Red Cedar	9.8	938	36	1,230	12,600	645,000
101	Doan Creek	Red Cedar	32.5	897	28	2,030	25,000	650,000
102	Doan Creek	Red Cedar	26,7	912	35	1,950	25,000	1,520,000
103	Dear Creek	Red Cedar	21.9	912	39	1,850	25,000	1,200,000
105		Maple	4.0	815	35	420	4,200	
107		Maple	10.1	800	15	500	3,000	
108		Maple	7.4	793	28	740	7,880	
109	Bear Creek	Maple	29.3	756	24	280	3,957	230,000
110	Sleep Hollow	Maple	11.1	793	26	815	9,861	3,751,400
115		Maple	5.3	720	25	-----	------	
		Maple	10.0			-----	------	
		Maple	12.0			-----	------	
		Maple	16.0			-----	------	
124	Batesse Creek	Portage	18.2	930	9	715	3,200	200,000
125	Batesse Creek	Portage	21.7	930	15	1,120	7,370	450,000
130	Upper	Upper Grand	5.3	920	11	170	1,010	200,000
131	Western Creek	Upper Grand	13.0	930	25	1,780	15,120	750,000
135		Upper Grand	3.2	920	28	250	2,480	
138	Indian Creek	Upper Grand	4.0	975	25	540	5,720	450,000
141	Otter Creek	Upper Grand	7.4	940	16	1,400	10,400	750,000
142		Upper Grand	3.1	910	35	360	4,510	
143		Upper Grand	3.7	910	22	530	3,410	
144	Columbia Creek	Upper Grand	14.8	900	38	980	11,700	700,000
146		Upper Grand	4.0	880	25	180	2,050	
148	Lookingglass R.	Lookingglass	15.2	870	17	400	2,500	170,000
149	Lookingglass R.	Lookingglass	9.8	870	23	530	3,670	230,000
151		Lookingglass	4.1	850	18	190	1,310	
153	Vermilion Creek	Lookingglass	49.9	840	22	1,400	10,805	600,000
154		Lookingglass	3.7	840	16	490	[illegible]	
155		Lookingglass	5.5	760	15	80	600	
158		Lookingglass	9.8	810	22	330	2,000	

Table III-11 (Cont'd)

RESERVOIR SITES INVENTORIED BY THE SOIL CONSERVATION SERVICE (CONTINUED)

SITE NO.	STREAM	SUB-BASIN	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
162	Bad Creek	Stony Creek	20.1	750	28	1,380	12,340	850,000
168		Stony Creek	4.5	720	28	330	3,420	
170	Batesse Creek	Portage	8.2	950	10	200	1,000	115,000
171	Portage River	Portage	30.1	920	6	2,200	7,800	
172	Butternut Drain	Thornapple	15.6	860	12	650	3,420	570,000
174		Thornapple	71.7	850	15	5,500	25,000	200,000
175		Thornapple	3.4	900	24	160	1,710	
177	Little Thornapple R	Thornapple	23.5	860	23	1,690	18,080	950,000
178	Little Thornapple R	Thornapple	28.8	860	26	2,040	23,650	1,250,000
179	Lacy Creek	Thornapple	11.2	900	38	1,050	14,090	650,000
180		Thornapple	9.1	880		750	7,760	600,000
182		Thornapple	6.8			110	1,230	
185		Thornapple	4.5			190	2,410	
186		Thornapple	2.5			140	3,040	
187		Thornapple	3.8			70	770	
190		Thornapple	2.9			20	210	
194	High Bank Creek	Thornapple	28.9	900		270	3,630	250,000
196		Thornapple	5.7			210	2,500	
197		Thornapple	3.7			470	3,740	
200		Thornapple	5.6			280	4,470	
201		Thornapple	2.9			70	2,260	
202		Thornapple	3.1			180	2,070	
203		Thornapple	7.3			130	1,620	
204		Thornapple	15.9	840		540	7,490	500,000
205		Thornapple	5.4			120	960	
206		Thornapple	6.4			240	3,510	
207	Bassett Creek	Thornapple	11.2	740		300	2,240	220,000
214		Thornapple	3.1			230	5,040	
219	Carrier Creek	Mid. Grand	10.9	840		320	3,760	450,000

Table III-11 (Cont'd)

RESERVOIR SITES INVENTORIED BY THE SOIL CONSERVATION SERVICE (CONTINUED)

SITE NO.	STREAM	SUB-BASIN	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
220		Mid. Grand	6.8			70	430	
222	Frayer Creek	Mid. Grand	11.4	820		190	3,250	650,000
223		Mid. Grand	8.4			40	520	
226		Mid. Grand	4.8			250	3,250	
227	Goose Creek	Mid. Grand	9.8	720		260	3,590	450,000
		Mid. Grand	4.5			-----	------	
		Mid. Grand	9.5			-----	------	
		Mid. Grand	---	---		-----	------	
234	Little Lib Hart Ck	Mid. Grand	10.9	740		100	1,400	400,000
235	Ballamy Creek	Mid. Grand	30.8	760		190	3,700	800,000
236	Ballamy Creek	Mid. Grand	31.8	740		350	12,500	2,500,000
237		Mid. Grand	4.7			80	2,030	
238		Mid. Grand	3.5			210	4,990	
239	Sessions Creek	Mid. Grand	17.1	720		220	4,520	850,000
240	Red Creek	Mid. Grand	9.3	720		300	8,970	1,600,000
241		Mid. Grand	7.7			250	4,880	
242		Mid. Grand	3.8			220	6,060	
243		Mid. Grand	4.1			20	210	
244	Black Creek	Flat	16.1	960		150	1,030	250,000
246		Flat	8.9	900		80	460	220,000
247		Flat	3.7			240	2,360	
248		Flat	4.1			270	6,620	270,000
249		Flat	8.1	800		240	2,500	300,000
			48.4			-----	------	
		Flat	36.1			-----	------	
		Flat	63.6			-----	------	
		Flat	6.0			130	2,350	
264		Rogue	5.7			90	1,330	
268		Rogue	6.7			450	7,330	

Table III-11 (Cont'd)

RESERVOIR SITES INVENTORIED BY THE SOIL CONSERVATION SERVICE (CONTINUED)

SITE NO.	STREAM	SUB-BASIN	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
269	Cedar Creek	Rogue	16.2	820		520	8,260	600,000
270	Cedar Creek	Rogue	25.3	800		800	13,720	1,000,000
271		Rogue	1.9			170	3,810	
272		Rogue	7.3			480	9,500	
273	Nash Creek	Rogue	12.5	800		1,100	22,010	1,400,000
277		Rogue	3.9			200	4,660	
278A		Rogue	9.2	835		680	17,570	1,400,000
		Low. Grand	13.2			-----	------	
		Low. Grand	17.9			-----	------	
282		Low. Grand	2.1			120	3,360	
284	Egypt Creek	Low. Grand	9.3	745		470	14,850	1,150,000
285		Low. Grand	2.0			140	3,340	
		Low. Grand	----			-----	------	
293		Low. Grand	2.1			125	3,410	
296		Low. Grand	3.5			130	2,650	
297A	Mill Creek	Low. Grand	10.7	780		520	5,400	450,000
303		Low. Grand	3.4			200	2,450	
305		Low. Grand	5.7			150	1,770	
308		Low. Grand	5.4			190	2,020	
309	Deer Creek	Low. Grand	25.8	640		1,360	21,880	
310		Low. Grand	6.7			130	1,660	
311		Low. Grand	4.5			110	1,650	
312		Low. Grand	2.1			130	2,100	
313		Low. Grand	4.0			80	1,420	
314		Low. Grand	5.1			130	1,100	
315	Bass Creek	Low. Grand	7.5	620		450	3,050	420,000
316	Bass Creek	Low. Grand	21.1	620		400	3,195	350,000
317	Bass Creek	Low. Grand	29.1	620		970	7,850	750,000

Table III-11 (Cont'd)

RESERVOIR SITES INVENTORIED BY THE SOIL CONSERVATION SERVICE (CONTINUED)

SITE NO.	STREAM	SUB-BASIN	DRAINAGE AREA (SQUARE MILES)	WATER SURFACE ELEVATION (FEET)	WATER DEPTH AT DAM (FEET)	WATER SURFACE AREA (ACRES)	STORAGE CAPACITY (ACRE-FEET)	ESTIMATED TOTAL COST
318	Crockery Creek	Low. Grand	28.4	740		750	7,740	550,000
320	Rio Grande Creek	Low. Grand	11.0	700		580	6,470	700,000
321	Rio Grande Creek	Low. Grand	18.6	660		150	2,340	350,000
322	Black Creek	Low. Grand	6.5			50	630	
323		Low. Grand	4.8			600	5,750	
324		Low. Grand	4.1			100	1,150	
325		Low. Grand	4.2			120	1,260	
326		Low. Grand	3.8			100	1,050	
328		Low. Grand	2.3			80	920	
330		Low. Grand	3.0			120	1,480	
331		Low. Grand	8.0			250	3,630	
332		Low. Grand	9.0	610		420	6,050	550,000
333		Low. Grand	4.1			200	2,360	
336		Low. Grand	3.5			90	1,020	

Table III-12

PURPOSES WHICH COULD BE SERVED BY DEVELOPMENT OF SPECIFIED SITES

Subarea	Site No.	Water Quality	Water Supply	Recreation	Fish and Wildlife	Flood Control	Agricul-tural	Total
#1	7	5*	2	3	4	4*	0	18
	8	3	1	2	2	3*	0	11
	9	4*	2	2	1	1	0	10
	10	4*	1	4	3*	1	0	13
	11	4*	2	2	3	1	0	12
	61	5*	2	2	5*	1	0	15
	62	5	0	5*	5*	2*	0	17
	171	4	0	1	4	1	1*	11
#2	5	4*	1	2	1	5*	0	13
	55	5*	3	2	1	1	0	12
	56	4*	1	2	1	1	0	9
	57	5*	3	2	4*	5*	0	19
	58	3*	2	1	1	5*	0	12
	59	3	1	3*	5*	1	0	13
	73	5	2	2	4*	4*	0	17
	142	2	2	2	5*	1	0	12
	144	0	1	1	5*	1	0	8
#3	1	3	1	3	1	5*	0	13
	2	2	0	2	2	4*	0	10
	3	2	0	2	2	4*	0	10
	4	2	0	2	2	4*	0	10
	4A	2	0	2	4*	1	1	10
	42	4	1	4*	5	2*	1	17
	45	2	2	2	2	2*	0	10
	46	3	0	1	4	5*	0	13
	47	2	1	3	4	3*	1	15
	47A	2	1	4*	5	2*	1	15
	51	2	0	5*	5*	3*	0	15
	49	2	1	2	3*	2*	4	14
	53	1	0	2	2	2*	0	7
	54	1	1	2	3	1*	0	8
	67	1	0	2	4*	1	0	8
	69	2	0	2	2	1	0	7
	109	1	1	3	5*	1	3*	14
	110	2	1	4	5*	1	3*	16
	148	1	1	5*	4*	1	0	12
	149	1	1	5*	4*	1	0	12
	162	1	0	2	3*	1	1	8

* Recommended as part of the single purpose plan.

Table III-12 (Cont'd)

Subarea	Site No.	Water Quality	Water Supply	Recreation	Fish and Wildlife	Flood Control	Agricul-tural	Total
#4	22	0	0	4	0	5*	0	9
	23	0	2	4	0	3	1	10
	25	0	0	3*	4*	1	1	9
	26	0	0	2	3	1*	1	7
	28	1	0	3	2	1*	0	7
	30	0	0	3	3	1	0	7
	31	0	0	3	4	1	1	9
	32	0	1	4	1	1	1	8
	35	0	1	3	4	1	1	10
	36	0	0	2	1	2*	1	6
	37	0	1	4	3	1	1	10
	65	0	0	5	0	5*	0	10
	179	0	2	4	4*	1	1	12
	180	0	1	3	5	1	1	11
#5	19	3	0	3*	5*	2*	0	13
	20	2	0	3	2	1*	0	8
	21	0	0	3	3	0	0	6
	38	2	3	4	0	2*	2	13
	39	1	0	3	1	1	2	8
	50	1	2	3	4	1*	2	13
	76	2	1	2	4	1*	2	12
	238	0	2	2	5*	1	0	10
	239	0	2	2	5*	1	0	10
	278A	2	0	3	3	1	1	10
	284	0	1	3	4*	1	1	10
#6	16	0	0	1	5*	0	1	7
	18	0	0	2	4*	0	1	7
	64	0	0	2	3*	0	1	6
	74	0	0	5*	5*	0	0	10
	316	0	0	1	4*	0	0	5
	321	1	0	1	3*	0	2	7

* Recommended as part of the single purpose plan.

10. <u>Impoundment Sites Suggested for Detailed Investigation Before 1975</u>.

a. <u>The Upper Grand River Reservoir System</u>. The proposed Upper Grand River Reservoir System would be comprised of a Jackson Reservoir Complex and a Red Cedar Reservoir Complex consisting of hydraulic structures totaling six reservoirs and six dams.

The Jackson reservoir complex would be comprised of three reservoirs; the lower, middle, and upper pools; and would be located on the Grand River and on Sandstone Creek at the confluence of the two streams. The confluence is about 12 miles upstream of the city of Eaton Rapids near Tompkins Center in Jackson County. The lower pool, which has been designated as the Onondaga Reservoir, would be on the Grand River and would be used to provide for flood control and water quality needs. The reservoir would also be used as a water supply source for pumpage into the middle pool. Its maximum pool elevation would be 905 feet above mean sea level. The middle pool, called Sandstone Reservoir, would be on Sandstone Creek and would be used as an upland storage reservoir to provide for water quality, recreation, and fish and wildlife needs. The Sandstone Reservoir would have a maximum pool elevation of 950. The upper pool, designated as the Minard Reservoir, would be located immediately upstream of the middle pool on Sandstone Creek and would be used to provide for recreation and fish and wildlife needs. The Minard Reservoir would have a maximum pool elevation of 950.

Releases from the lower and middle pools would be made during periods of low flows to increase the water supply and to improve the water quality of the stream. The combined storage capacity of the three pools comprising the Jackson Reservoir Complex would be 153,000 acre-feet of water having a surface area of 11,900 acres. In order to maintain a high dissolved oxygen content in the three pools, the relocation of the City of Jackson and Jackson State Prison sewage treatment plant outfalls would be required. Having the outfalls relocated downstream of the proposed reservoirs would result in a two-fold benefit: first, some recreation and fish and wildlife needs would be provided in the lower pool; and second, the pollutional effect of the river downstream of the outfalls

would be alleviated since low flows would be augmented as a result of releases from the reservoirs. The general arrangement of the Jackson Reservoir Complex is shown on Plate Q-39. Data pertaining to pool elevation, storage volume and surface area for the pools are presented in Tables III-13 thru III-15.

The water quality benefits at Jackson are based on having the City of Jackson and Jackson State Prison sewage treatment plant effluents discharged to the Grand River downstream of the proposed Onondaga Reservoir dam where low flow augmentation would be provided. Augmenting the low flows would avert an expenditure of $1,600,000 now and $2,200,000 in 1995 for incremental advanced waste treatment costs at Jackson. The average annual operation and maintenance costs of the incremental advanced waste treatment would be $210,000. The average annual cost averted, and therefore the average annual benefit, would be $334,600.

The Red Cedar reservoir complex would be comprised of three reservoir pools located on the Red Cedar River upstream of East Lansing and on Doan Creek in the vicinity of the community of Okemos. The proposed Red Cedar Reservoir Complex would include: the lower pool, Okemos Reservoir, would be on the main stem of the river; the middle pool, Williamston Reservoir, would be on the main stem of the river upstream of Okemos and the city of Williamston; and the upper pool, Doan Creek Reservoir, would be on Doan Creek, a tributary of the Red Cedar River just upstream of Williamston. Data concerning pool elevation, storage volume and surface area for the pools are presented in Tables III-16 thru III-18. Plate Q-40 shows the general location of the proposed Red Cedar Reservoir Complex.

The lower pool, Okemos Reservoir, would be used to provide for flood control and recreation needs; the maximum pool elevation would be 865 feet above mean sea level. The middle pool, Williamston Reservoir, would be a fluctuating pool as it would be used for water quality storage, recreation, fish and wildlife, and a water supply source for filling the lower pool; the maximum pool elevation would be 884. The upper pool, Doan Creek Reservoir, would be managed to meet the demands of recreation and fish and wildlife; the maximum pool elevation would be 900. The combined storage capacity of the three pools comprising the Red Cedar Complex would be 104,000 acre-feet having a surface area of 13,060 acres.

The wastewater flow for Lansing in the year 2020 is estimated to be 118 MGD. Incremental advanced waste treatment has been identified as the least costly alternative for meeting future water needs at Lansing. This type of treatment for a flow of 118 MGD is estimated to cost $3,400,000 now and $5,600,000 in 1995. The average annual operation and maintenance cost of the incremental advanced wastewater treatment would be $160,000 per year. The average annual cost averted, and therefore the average annual water quality benefit at Lansing, would be $439,500.

The total cost of the proposed Upper Grand River Reservoir System is estimated to be $69,417,689. Total average annual costs are $3,308,000 and total average annual benefits are $3,967,400 which yields a benefit/cost ratio of 1.20. A summary of the average annual costs and average annual benefits for the proposed Upper Grand River Reservoir System is presented in Table III-19.

TABLE III-13

SUMMARY OF DATA ON RESERVOIR SITE 62M
(Minard)

GENERAL	
Stream	Sandstone Creek
River mile	6
Drainage area (square miles)	87
ELEVATION (feet above mean sea level)	
Top of dam	954
Maximum pool	950
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife pool	950
Stream bed	918
STORAGE (acre feet)	31,500
Flood control	N/A
Water quality	N/A
Recreation and fish and wildlife	31,500
SURFACE AREA (acres)	
Maximum pool	3,000
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	3,000
PERIMETER	
Perimeter of maximum pool (miles)	49
DESIGN DATA	
Length of dam	3,490
Side slopes (horizontal/vertical)	upstream 3:1, downstream 2.5:1
Gates, number and size (feet)	13-10X10-Tainter
Crest elevation (feet above mean sea level)	941
Apron elevation (feet above mean sea level)	918
Discharge at maximum pool (cubic feet per second)	6,970

TABLE III-14

SUMMARY OF DATA ON RESERVOIR SITE 62S
(Sandstone)

GENERAL	
Stream	Sandstone Creek
River mile	2
Drainage area (square miles)	87
ELEVATION (feet above mean sea level)	
Top of dam	954
Maximum pool	950
Top flood control pool	N/A
Top water supply and water quality pool	950
Top recreation and fish and wildlife pool	943
Stream bed	896
STORAGE (acre feet)	91,500
Flood control	N/A
Water supply and water quality	30,000
Recreation and fish and wildlife	61,500
SURFACE AREA (acres)	
Maximum pool	4,800
Top flood control pool	N/A
Top water supply and water quality pool	4,800
Top recreation and fish and wildlife	N/A
PERIMETER	
Perimeter of maximum pool (miles)	39
DESIGN DATA	
Length of dam	3,290
Side slopes (horizontal/vertical)	upstream 3:1, downstream 2.5:1
Gates, number and size (feet)	4-6X8 - sluice
Crest or invert elevation (feet above mean sea level)	920
Apron elevation (feet above mean sea level)	896
Discharge at maximum pool (cubic feet per second)	5,860

TABLE III-15

SUMMARY OF DATA ON RESERVOIR SITE 7
(Onondaga)

GENERAL	
Stream	Grand River
River mile	191
Drainage area (square miles)	560
ELEVATION (feet above mean sea level)	
Top of dam	909
Maximum pool	905
Top flood control pool	905
Top water supply and water quality pool	N/A
Top recreation and fish and wildlife pool	N/A
Stream bed	883
STORAGE (acre feet)	30,200
Flood control	30,000
Water supply and water quality	N/A
Recreation and fish and wildlife	200
SURFACE AREA (acres)	
Maximum pool	4,100
Top flood control pool	4,100
Top water supply and water quality pool	N/A
Top recreation and fish and wildlife	
PERIMETER	
Perimeter of maximum pool (miles)	74
DESIGN DATA	
Length of dam	3,100
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	12-10X13- Tainter
Crest elevation (feet above mean sea level)	896
Apron elevation (feet above mean sea level)	888
Discharge at maximum pool (cubic feet per second)	33,200

TABLE III-16

SUMMARY OF DATA ON RESERVOIR SITE 59
(Doan)

GENERAL	
Stream	Doan Creek
River mile	2
Drainage area (square miles)	42
ELEVATION (feet above mean sea level)	
Top of dam	904
Maximum pool	900
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife pool	900
Stream bed	864
STORAGE (acre feet)	34,200
Flood control	N/A
Water quality	N/A
Recreation and fish and wildlife	34,200
SURFACE AREA (acres)	
Maximum pool	2,600
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	2,600
PERIMETER	
Perimeter of maximum pool (miles)	38
DESIGN DATA	
Length of dam	3,630
Side slopes (horizontal/vertical)	upstream 3:1; downstream 25.1:1
Gates, number and size (feet)	1-7X6 - Tainter
Crest elevation (feet above mean sea level)	885
Apron elevation (feet above mean sea level)	864
Discharge at maximum pool (cubic feet per second)	930

TABLE III-17

SUMMARY OF DATA ON RESERVOIR SITE 58
(Williamston)

GENERAL	
Stream	Red Cedar River
River mile	25
Drainage area (square miles)	235
ELEVATION (feet above mean sea level)	
Top of dam	888
Maximum pool	884
Top flood control pool	884
Top water supply and water quality	N/A
Top recreation and fish and wildlife pool	N/A
Stream bed	850
STORAGE (acre feet)	58,000
Flood control	20,000
Water supply and water quality	30,000
Recreation and fish and wildlife	8,000
SURFACE AREA (acres)	
Maximum pool	8,700
Top flood control pool	8,700
Top water supply and water quality pool	N/A
Top recreation and fish and wildlife	N/A
PERIMETER	
Perimeter of maximum pool (miles)	108
DESIGN DATA	
Length of dam	1,950
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	8-10X8 - Tainter
Crest elevation (feet above mean sea level)	866
Apron elevation (feet above mean sea level)	850
Discharge at maximum pool (cubic feet per second)	15,370

TABLE III-18

SUMMARY OF DATA ON RESERVOIR SITE 57C
(Okemos)

GENERAL	
Stream	Red Cedar River
River mile	14
Drainage area (square miles)	295
ELEVATION (feet above mean sea level)	
Top of dam	869
Maximum pool	865
Top flood control pool	865
Top water supply and water quality pool	N/A
Top recreation and fish and wildlife pool	N/A
Stream bed	830
STORAGE (acre feet)	11,800
Flood control	10,000
Water supply and water quality	
Recreation and fish and wildlife	1,300
SURFACE AREA (acres)	
Maximum pool	1,760
Top flood control pool	1,760
Top water supply and water quality pool	N/A
Top recreation and fish and wildlife	
PERIMETER	
Perimeter of maximum pool (miles)	13
DESIGN DATA	
Length of dam	2,750
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	13-7X11 -Tainter
Crest elevation (feet above mean sea level)	857
Apron elevation (feet above mean sea level)	820
Discharge at maximum pool (cubic feet per second)	16,310

TABLE III-19

SUMMARY OF ECONOMIC DATA
ON THE
UPPER GRAND RIVER RESERVOIR SYSTEM

ECONOMIC DATA

Average annual benefits:	
Recreation	$2,289,000
Water quality	774,000
Water supply	412,000
Flood control	300,000
Fish and wildlife	192,000
Total	3,967,000
Average annual cost	3,308,000
Benefit/cost ratio	1.20

b. Sleepy Hollow Reservoir. The proposed Sleepy Hollow Reservoir, Site No. 110, has been included in the Upper Maple River Watershed, PL-566 Work Plan. The reservoir would be located on the Little Maple River south of the confluence of the Little Maple River and the Maple River in the eastern part of Clinton County. The reservoir structure would be a multi-purpose flood prevention and recreation development and would drain an area of 11.1 square miles. The storage capacity of the reservoir would be 9,861 acre-feet of water and would have a surface area of 415 acres. For maximum conditions, the pool elevation would be 793. The recreation development would include a 415 acre lake and a 1-1/2 mile wide by 3 mile long recreation area. Major uses of the recreation area include camping, picnicking, swimming, boating, fishing, hiking, and limited small game hunting. The location of the proposed reservoir is shown on Plate Q-42. The total first cost of the proposed reservoir is estimated to be $3,885,000. Total average annual costs are $197,400 and total average annual benefits are $1,360,700 which yield a benefit/cost ratio of 6.87.

c. Columbia Creek Reservoir. The proposed Columbia Creek Reservoir, Site No. 144 would be located on the Columbia Creek, an upper tributary of the Grand River, in Aurelius Township, Ingham County. The reservoir would be used to provide for public recreation needs. It would have a storage capacity of 11,700 acre-feet of water and would have a surface area of 130 acres. When filled to its capacity, the reservoir would have a pool elevation of 885. At that elevation, the reservoir would not impair the draining of croplands north of Curtice Road. Construction of the proposed reservoir as planned would raise a section of Curtice Road. About five houses, an Ingham County Gravel Pit, and the Columbia Creek Park are located in the area that would be occupied by the reservoir. The location of the proposed Columbia Creek Reservoir is shown on Plate Q-43.

The total first cost of the reservoir structure is estimated to be $1,320,000. Total average annual costs are $99,300 and total average annual benefits are $207,800 which yield a benefit/cost ratio of 2.09.

d. Portage River Reservoir. The proposed Portage River Reservoir, Site No. 171, would be located on the Portage River in Waterloo

Township of Jackson County. The Michigan Department of Natural Resources has indicated interest in the site as a potential single-purpose fish and wildlife development. The proposed reservoir would have a storage capacity of 7,800 acre-feet of water which would have a surface area of 2,200 acres. Since there are no natural areas where deep open water will be maintained, it is planned that about 5.5 miles of level ditching, approximately 6 feet deep, would be constructed in the proposed flooding area. The excavated material from the ditches would be used to build small islands for wildlife nesting purposes. The development of the site would require that portions of the Woeckel, Reithmiller, and Waterloo-Munith Roads be raised.

The proposed Portage River reservoir would be located on land largely owned by the State. The total first cost of the reservoir structure, not including land costs, is estimated at $156,000. The average annual costs are $15,300 and the average annual benefits are $45,600 which result into a benefit/cost ratio of 2.98.

II. <u>Impoundment Sites Suggested for Detailed Investigation Before 1980.</u>

a. <u>Prairie Creek Reservoir</u>. The proposed Prairie Creek Valley Preserve, heretofore outlined, would extend from the confluence of the Grand River and Prairie Creek along the latter stream up to the proposed earthen dam for the Prairie Creek Reservoir, Site No. 42. The dam would be located in Ionia Township, Ionia County, 1.5 miles north and 1/4 mile east of the confluence. The Prairie Creek Reservoir is proposed as a second project on the Creek and would extend eight river miles upstream from the dam. This reach of Prairie Creek is in a narrow deep valley, with steep sides. The average height of the valley upstream from the dam is 50 feet; the area drained by the creek is 100 square miles. The surrounding land is gently rolling and undulatory; the soils are glacial driftsands, silty loams, and gravel. Population is sparse - no communities or villages are involved.

The proposed reservoir would be used to impound water for recreation, fish and wildlife habitat, and flood control. The dam for the reservoir would be constructed across the creek to a height of 105 feet above the stream bed at elevation 755 feet above mean sea level. The

impoundment would extend upstream about eight miles. The reservoir would contain about 61,900 acre-feet and would have a surface area of 1,820 acres at a maximum pool elevation of 750. The average pool depth of the reservoir would be 34.0 feet, and the perimeter of the shoreline encompassing the reservoir would be 17.6 miles, at maximum elevation. Data on the proposed reservoir concerning pool elevation, storage volume, and survace area are presented in Table III-20.

To provide for anticipated flood flow, 10,000 acre-feet of water would be released, reducing the pool level elevation to 746 and the surface area to 1,200 acres. The perimeter of the shoreline would be 43.1 feet. The 746 foot pool elevation would be the generally prevailing condition.

A spillway would be incorporated into the dam capable of discharging 20,700 cubic feet per second, which is the design flood peak. The flow would be controlled by three 20 x 20 foot tainter gates. A plan of the reservoir and features of the dam are shown on Plates Q-45 and Q-46 respectively.

With the pool at elevation 746 feet many use-days of recreation would be provided. Recreation would consist of camping, picnicking, swimming, hiking, sailing, waterskiing, general boating and nature interpretation. Fish and wildlife activities would provide 29,000 days of fishing and 2,800 days of hunting.

It is estimated that average annual benefits would be: for recreation $662,000; for fish and wildlife $42,000; and for flood control $40,000. These sums total $744,000 in average annual benefits.

The total first cost of the project is estimated to be $6,800,000; total average annual costs are estimated to be $691,300.

The total average annual benefits of $744,000 and total average annual costs of $691,300 yield a benefit/cost ratio of 1.08.

The water flows fast in Prairie Creek and the stream bed is loose gravel. These conditions are reported to be desirable for anadromous fish spawning habitat. This potential exists in many of the Grand River tributaries and some reaches on the main stream. Prairie Creek has some native brown trout in its upper reaches; it could well develop into one of the best quality reserves in the Basin.

Saranac Sand and Gravel Company, now operated by the Williams Brothers Asphalt Company, produces large quantities of sand and gravel for concrete construction and fill. Their equipment is both stationary and portable. There may be a conflict of interest in mineral sources between Saranac and Site No. 42.

The reservoir would inundate eight rural roads and necessitate the relocation of seven houses. There are no railroads or pipelines in the area requiring relocation because of flooding.

TABLE III-20

SUMMARY OF DATA ON RESERVOIR SITE 42
(Prairie Creek)

GENERAL	
Stream	Prairie Creek
River mile	3
Drainage area (square miles)	100
ELEVATION (feet above mean sea level)	
Top of dam	755
Maximum pool	750
Top flood control pool	750
Top water quality pool	N/A
Top recreation and fish and wildlife pool	746
Stream bed	650
STORAGE (acre feet)	61,900
Flood control	10,000
Water quality	N/A
Recreation and fish and wildlife	51,900
SURFACE AREA (acres)	
Maximum pool	1,815
Top flood control pool	1,815
Top water quality pool	N/A
Top recreation and fish and wildlife	1,200
PERIMETER	
Perimeter of maximum pool (miles)	18
DESIGN DATA	
Length of dam	N/A
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	3-20X20 - Tainter
Crest elevation (feet above mean sea level)	730
Apron elevation (feet above mean sea level)	650
Discharge at maximum pool (cubic feet per second)	20,700
ECONOMIC DATA	
Average annual benefits:	
Recreation	$662,000
Fish and wildlife	42,000
Flood control	40,000
Total	744,000
Average annual cost	691,300
Benefit/cost ratio	1.08

b. Portland Reservoir. The Lookingglass River rises in the northwest corner of Livingston County. From here the stream flows north to a point three miles west and one mile south of the village of Baucroft. Here it turns to the west and flows in a meandering course to its confluence with the Grand River at the city of Portland, Grand River mile 112.8. The length of the Lookingglass River channel is 61 miles and it drains 312 square miles. The dam for the proposed Portland Reservoir, Site No. 51, would be constructed across the Lookingglass River, one mile upstream from its confluence with the Grand River just outside of Portland.

The topography of the watershed is distinctly different in the upper and lower half of the 61 mile Lookingglass River reach. In the lower half the watershed is comparatively narrow in width with steep slopes. The upper half of the basin is likewise narrow but very flat with extensive areas of marsh and wetlands. For the most part the soils are loam, clayloam, and silty clayloam, and are the products of glaciation and weathering. Drainage ranges from good in hilly parts to poor in depressed areas. With the exception of extensive upland tracts of unproductive wetlands, the watershed is used for farming. Near the proposed dam, urbanization with high quality residences is taking place, but most of the watershed is thinly settled, with a few small villages.

The proposed Portland reservoir would provide flood control, improved water quality, fish and wildlife habitat, and recreation. The site is within a half hour drive of Lansing and has many excellent highway access routes including Interstate Highway 96.

The proposed Portland Reservoir earthen dam would be 2,330 feet long and 52 feet above the stream bed at elevation 765 feet above mean sea level. During normal times the water would be partially impounded and thereby maintained at elevation 751. During low flow periods, 4,000 acre-feet of water could be released to augment low flows downstream of the dam. There would remain 12,700 acre-feet in the reservoir for the "conservation pool," which is considered adequate. Normally, the pool would be at elevation 751 feet with a water surface

area of 1,300 acres and an average depth of 12.8 feet. When a flood occurred, the flow over the dam would be regulated and the water level of the Lookingglass River would be allowed to rise to elevation 760 feet. This would be temporary and would total 36,700 acre-feet of water. The surface area of the water then would be 3,230 acres.

The dam would include a 144 foot long spillway equipped with two 20 x 50 foot tainter gates and one 20 x 35 foot tainter gate that could pass a discharge of 47,400 cubic feet per second.

Data pertaining to pool elevation, storage volume, and surface area are presented in Table III-22. A plan of the reservoir and features of the dam are shown on Plates Q-47 and Q-48 respectively.

The impoundment of water in the reservoir would flood 1.2 miles of Interstate Highway I-96 and 0.7 miles of Chesapeake and Ohio Railroad tracks necessitating relocation or raising or both. The following rural roads would be inundated: Cutter, Peake, Chadwick, Monroe, Clintonia, and Jones. Twenty-five structures are within the proposed site.

The purposes of the project would be to control floods to improve water quality on the Lookingglass River, to improve and promote fish and wildlife, and to provide public recreation facilities. The average annual flood control benefits are estimated to be $56,000. Improvement in water quality would also be effected at Portland.

Total average annual benefits are estimated to be $980,000. It is estimated that construction costs for this project would amount to $3,861,000. An additional $9,192,000 would be required for recreational facilities, making a total of $12,275,000. The total average annual costs are estimated to be $603,600. The total average annual benefits of $980,000 and total average annual costs of $603,600 yield a benefit/cost ratio of 1.91.

Table III-21

PRELIMINARY RESERVOIR COSTS	Basin: GRAND RIVER	Tributary: Lookingglass River
Design Water Surface Elevation: 760 ft.	Site: Portland (MWRC)	No: 51
Main Dam Height: 53 ft.	Main Dam Length: 2330 ft.	Shoreline Length: 38.2 Miles
Water Surface Area: 3230 Acres	Storage: 36,700 Acre feet	Islands: No. 1 Acres 176

REMARKS:

RESERVOIR COSTS

Description	Unit	Unit Price	Quantity	Cost	REMARKS
A. Land and Damages:					
1. Land Costs (fee)					
(a) Inundated	Acres	$ 208	3406	$ 710,000	
(b) 300 Foot Strip	Acres	208	1400	292,000	
2. Land Cost (Easement)	Acres				
3. Non-farm Homes	Each	500	21	10,500	
4. Resettlement	Each				
5. Other					
6. Acquisition	8 % of Items A(1-5)			81,000	
7. Contingencies	25 % of Items A(1-6)			273,400	
	SUBTOTAL ITEM A			$1,336,900	
B. Relocations:					
1. Highways					
(a) Primary (4 Lane)	Miles	310,000	1.2	372,000	I-96 - Raise to dike with loss of AF
(b) Secondary (2 Lane)	Miles				
(c) Bridges					
New	Each				
Raised	Each				
Removal	Each				
(d) Culverts	Feet				
(e) Other					
	SUBTOTAL ITEM B(1)			$ 372,000	
2. Railroads					
(a) Track	Mile	120,000	0.7	84,000	Raise to form Dike at tracks
(b) Bridges					
New	Each				
Raised	Each				
Removal	Each				
(c) Culverts	Feet				
(d) Other					
	SUBTOTAL ITEM B(2)			$ 84,000	
3. Utilities					
(a) Natural Gas	Feet				
(b) Petroleum	Feet				
(c) Power	Feet				
(d) Water	Feet				
(e) Telephone	Feet				
(f) Sewers	Feet				
(g) Others					
	SUBTOTAL ITEM B(3)			$	

Table III-21 (Cont'd)

PRELIMINARY RESERVOIR COSTS	Site: Portland (MWRC) 760	W.S. Elev.	No: 51

RESERVOIR COSTS (CONT'D)

Description	Unit	Unit Price	Quantity	Cost	REMARKS
B. Relocations (Cont'd):					
4. Miscellaneous					
(a) Cemeteries					
(b)					
(c)					
	SUBTOTAL ITEM B(4)			$	
	SUBTOTAL ITEM B			$456,000	
C. Reservoir Clearing:					
1. Farmland	Acre	50	2261	113,000	
2. Woodland - light	Acre	150	646	97,000	
3. Woodland - heavy	Acre	300	323	97,000	
4. Grubbing	Acre				
5. Structures					
Houses	Each	100	21	2,100	
Commercial Buildings	Each				
6. Other					
	SUBTOTAL ITEM C			$309,100	
D. Dam and Appurtenant Costs:					
1. Spillway	Lump Sum			582,900	
2. Dam	Lump Sum			285,800	
3. Dikes	Lump Sum			10,000	
4. Other					
	SUBTOTAL ITEM D			$878,700	
E. Access Road:					
1. Road	Mile	50,000	0.5	25,000	
2. Bridge	Each				
3. Culvert	Feet				
4. Other					
	SUBTOTAL ITEM E			$ 25,000	
F. Miscellaneous:					
1.					
2.					
3.					
4.					
	SUBTOTAL ITEM F			$	

SUMMARY

	Item Amount	Running Total
1. Items (B - F)	$ 1,668,700	$ 1,668,700
2. Contingencies 25% of Items (B - F)	$ 417,200	$ 2,085,900
3. Engineering & Design 10 % of Running Total Line 2	$ 208,600	$ 2,294,500
4. Supervision & Administration 10 % of Running Total, Line 3	$ 229,400	$ 2,523,900
5. Item A	$ 1,336,900	$ 3,860,800
	GRAND TOTAL	$ 3,861,000
	COST PER ACRE FOOT	$ 105

Table III-22

SUMMARY OF DATA ON RESERVOIR SITE 51
(Portland)

GENERAL	
Stream	Lookingglass River
River mile	1
Drainage area (square miles)	312
ELEVATION (feet above mean sea level)	
Top of dam	765
Maximum pool	760
Top flood control pool	760
Top water quality pool	N/A
Top recreation and fish and wildlife pool	751
Stream bed	712
STORAGE (acre feet)	36,700
Flood control	20,000
Water quality	N/A
Recreation and fish and wildlife	16,700
SURFACE AREA (acres)	
Maximum pool	3,230
Top flood control pool	3,230
Top water quality pool	N/A
Top recreation and fish and wildlife	1,300
PERIMETER	
Perimeter of maximum pool (miles)	38
DESIGN DATA	
Length of dam	2,330
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	2-20X50 - Tainter
Crest elevation (feet above mean sea level)	740
Apron elevation (feet above mean sea level)	702
Discharge at maximum pool (cubic feet per second)	47,400
ECONOMIC DATA	
Average annual benefits:	
Recreation	$877,000
Flood control	56,000
Fish and wildlife	47,000
Total	980,000
Average annual cost	603,600
Benefit/cost ratio	1.91

c. Sand Creek Reservoir. Sand Creek rises in Chester Township, Muskegon County. From here it flows south 12 miles and east 3/4 mile to its confluence with the Grand River in Tallmadge Township, Ottawa County. This confluence is at 28-1/2 river miles of the Grand River and 5.5 miles northwest of the heart of Grandville. The proposed Sand Creek Reservoir, Site No. 74, would include an earthen dam located 3/4 mile south of where the State Highway M-45 bridge crosses Sand Creek, in Tallmadge Township. Above the proposed dam, Sand Creek drains a watershed of 41 square miles.

The topography of the proposed reservoir site is hilly and undulatory. Most of the site area is a 60 to 80 foot deep valley which broadens substantially at three well-defined reaches. The valley is densely wooded on both sides. Open areas flanking both sides are cultivated and include a conservation club. A few small areas are marsh, but in general drainage is good. The soil is sandy glacial drift. Population is sparse; Tallmadge and Marne are the only communities here, and there is no commerce or industrial development in the area.

The proposed Sand Creek reservoir would be used to implement water for recreation and for fish and wildlife. The reservoir would result from the construction of a 2,100 foot long earthen dam across Sand Creek to a height of 66 feet above the stream bed at elevation 664. The reservoir would contain 29,600 acre-feet of water and would have a surface area of 1,470 acres at the maximum pool elevation of 660. The average depth of the pool would be 20.1 feet. The perimeter of the shoreline encompassing the pool would be 28.5 miles.

Considering recreation, fish and wildlife and the above mentioned enhancements, average annual benefits totalling $934,000 are estimated to be realized.

The proposed elevation of the dam is 665 feet in order to realize the largest capacity at the lowest unit cost. The estimated first cost of the reservoir is $4,107,000; recreational site development is estimated to cost $8,712,000. These amount to a total of $12,819,000; the total average annual cost, based on a 100-year project life, is estimated to be $630,300.

The total average annual benefits of $934,000 and the total average annual costs of $630,300 result in a benefit/cost ratio of 1.48.

This project may be within the surface boundary of a producing oilfield. Producing and discontinued wells should be located and checked to ensure against brine or oil seepage from wells or loss of surface water into discontinued wells.

Into the dam would be built a spillway capable of passing 11,600 cfs. One tainter gate, 20 feet high and 35 feet wide, would control and regulate the flow.

This pool would be constant all the time; with its proximity to Grand Rapids, Holland, and Muskegon, exceptional opportunities for public usage would be available.

Data concerning this proposed improvement are given in Table III-23.

In order to develop this project some existing facilities must be altered. Certain highways, electric power lines, and water transmission pipes would have to be relocated or adjusted. Numerous oil wells would have to be protected or abandoned in the reservoir area. A small golf course and sportsman's area on Johnson Street would have to be abandoned. At the communities of Marne and Tallmadge some few homes would have to be relocated; a small privately owned reservoir in Tallmadge would have to be abandoned. The community of Marne, at the upper end of the reservoir, is now constructing a waste disposal system. Some means would have to be developed here to protect the quality of water of the proposed pool.

A plan of the reservoir and features of the dam are shown on Plates Q-49 and Q-50 respectively.

Urbanization adjacent to the site could be expected, by reason of its proximity to Grand Rapids. Other communities of significance within 30 miles are East Grand Rapids, Grand Haven, Grandville, Holland, Kentwood, Muskegon, and Rockford. Grand Valley State College is but three miles distant. A number of intangible benefits would accrue due to the improvement. They are:

(1) Development of marginal lands.

(2) Improved water quality resulting from more stabilized stream flow.

(3) Economic influx to area because of recreational facilities.

(4) Area advancement by increase of water resources.

(5) Creation of limited reservoir water storage for flood control within the area. Camp Optimist, an existing day camp of 120 acres, and Grand Rapids Camp Aman, a large natural park, would benefit from the additional water resources.

d. Bear Creek Reservoir. The proposed Bear Creek Reservoir, Site No. 109, has been incorporated into the Upper Maple River Watershed, PL-566, Work Plan. The reservoir will be located on Bear Creek about one mile south of the confluence of the creek with the Maple River in the western part of Shiawassee County. The reservoir structure will be a multi-purpose earthen dam for flood prevention and recreation and will control a drainage area of 29.3 square miles. Its storage capacity will be 3,957 acre-feet of water. The water surface area will be 280 acres. When filled to its capacity, the reservoir will have a pool elevation of 756. The recreation area is two miles long and more than a mile wide covering some 1,320 acres of gently rolling land. The major use of the Bear Creek recreation area includes small game hunting, fishing, boating, swimming, picnicking, and primitive area camping. The location of the proposed reservoir is shown on Plate III-41.

The total first cost of the proposed reservoir is estimated to be $2,455,000. Total average annual costs are $120,700 and total average annual benefits are $340,200 which yield a benefit/cost ratio of 2.82.

Table III-23

SUMMARY OF DATA ON RESERVOIR SITE 74
(Sand Creek)

GENERAL	
Stream	Sand Creek
River mile	1
Drainage area (square miles)	41
ELEVATION (feet above mean sea level)	
Top of dam	664
Maximum pool	660
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife pool	660
Stream bed	598
STORAGE (acre feet)	29,600
Flood control	N/A
Water quality	N/A
Recreation and fish and wildlife	29,600
SURFACE AREA (acres)	
Maximum pool	1,470
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	1,470
PERIMETER	
Perimeter of maximum pool (miles)	29
DESIGN DATA	
Length of dam	2,100
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	1-20X35 - Tainter
Crest elevation (feet above mean sea level)	640
Apron elevation (feet above mean sea level)	588
Discharge at maximum pool (cubic feet per second)	11,600
ECONOMIC DATA	
Average annual benefits:	
Recreation	$877,000
Fish and wildlife	57,000
Total	934,000
Average annual cost	689,000
Benefit/cost ratio	1.36

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e. No Name Creek Reservoir. The proposed No Name Creek Reservoir, Site No. 180, would be located about eight miles northeast of Vermontville and eight miles southwest of Grand Ledge in Chester Township, Eaton County. The stream on which the reservoir would be located has been unofficially designated as No Name Creek. It flows generally southwest to its confluence with the Thornapple River 0.5 miles below the junction of the Little Thornapple and Thornapple Rivers. The drainage area above the dam is nine square miles of hilly, undulating, and sparsely settled land used mostly for agriculture. Small acreage is forested; there are no urban settlements. The soils of the drainage area are loamy glacial till with moderate productive capacity for farming. The creek is moderately incised into the till plain; land adjacent to the site is gently rolling.

The proposed reservoir would be used to provide recreation for the public and to create fish and wildlife habitat for fishing and hunting generally. The reservoir would have a 2025 foot long earthen dam constructed across the creek to a height of 33 feet above the stream bed and at elevation 885 feet above mean sea level. The reservoir would contain 7,760 acre-feet of water, and would have a surface area of 750 acres at a maximum pool elevation of 880. The average depth of the pool at maximum storage would be 10.3 feet. The water impoundment would extend 2 miles upstream from the dam and the perimeter of the shoreline encompassing the pool would be 13 miles. The impoundment would have the capacity for six inches of water runoff; one year would be required to fill the reservoir. Data pertaining to pool elevation, storage volume, and surface area are presented in Table III-24. A plan of the reservoir and features of the dam are shown on Plates Q-51 and Q-52 respectively.

It is estimated that annual benefits derived from recreation would be $432,000 and that fish and wildlife benefits would be $30,000 for a total annual benefit of $462,000.

The estimated cost of the land and structures would be $800,000. Recreation facilities including land would cost $4,598,000 in the initial phase. Thus, total costs would be $5,398,000 resulting in an average annual cost of $265,400.

Total average annual benefits of $462,000 and total average annual costs of $265,400 would result in a benefit/cost ratio of 1.74.

Table III-24

SUMMARY OF DATA ON RESERVOIR SITE 180
(No Name Creek)

GENERAL	
Stream	No Name Creek
River mile	1
Drainage area (square miles)	9
ELEVATION (feet above mean sea level)	
Top of dam	885
Maximum pool	880
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife pool	880
Stream bed	851
STORAGE (acre feet)	7,760
Flood control	N/A
Water quality	N/A
Recreation and fish and wildlife	7,760
SURFACE AREA (acres)	
Maximum pool	750
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	750
PERIMETER	
Perimeter of maximum pool (miles)	13
DESIGN DATA	
Length of dam	2,025
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	1-10X30 - Tainter
Crest elevation (feet above mean sea level)	870
Apron elevation (feet above mean sea level)	846
Discharge at maximum pool (cubic feet per second)	3,640
ECONOMIC DATA	
Average annual benefits:	
Recreation	$432,000
Fish and wildlife	30,000
Total	462,000
Average annual cost	290,000
Benefit/cost ratio	1.59

12. Impoundment Sites Suggested for Detailed Investigation Before 1985.

a. Ravenna Reservoir. The North Branch of Crockery Creek rises in the northwestern part of Kent County and flows in a southwesterly direction about 10 miles to its confluence with Crockery Creek just west of the village of Ravenna in Muskegon County. From there, Crockery Creek flows southwest to its confluence with the Grand River at 12.5 river miles on the Grand River. The dam for the proposed Ravenna Reservoir, Site No. 16, would be located 1/4 mile east of Ravenna on the North Branch of Crockery Creek in Muskegon County. The reservoir would have an upstream watershed of 45.5 square miles. The land is undulatory with rolling hills, some woodlands and some grasslands. The area is sparsely populated with no towns or villages of appreciable size.

The proposed reservoir would be used to impound water for recreation, irrigation, and fish and wildlife uses. The reservoir would have a 991 foot long earthen dam constructed across the North Branch of the Creek to elevation 685 which would be 39 feet above the stream bed. The water impoundment would extend upstream about 2-1/2 miles. The reservoir would contain 5,800 acre-feet of water and would have a surface area of 390 acres at the maximum pool elevation of 680 feet. The average pool depth of the reservoir would be 14.2 feet. Data pertaining to pool elevation, storage volume, and surface area are presented in Table III-25 and on Plate Q-8. At the maximum pool elevation of 680 feet, the perimeter of the shoreline encompassing the pool would be about 10 miles.

The dam would be controlled by two 15 x 30 foot tainter gates that could pass a maximum discharge of 12,300 cubic feet per second. The dam would be operated so as to provide for storage of 450 acre-feet of irrigation water and for storage of 5,350 acre-feet of water, at a pool elevation of 679 feet, for recreation and fish and wildlife needs. A plan of the reservoir and features of the dam are shown on Plates Q-53 and Q-54.

As stated above, the reservoir would be used to meet recreation, irrigation, and fish and wildlife needs. It is estimated that 14,200 days of fishing and 760 days of hunting would be spent here annually.

Four hundred fifty acre-feet of the reservoir water have been allotted for irrigating adjacent farm lands. Taking advantage of available irrigation; vegetables, cucumber, melons, potatoes, strawberries, and fruit could be grown nearby.

The first cost of construction is estimated to be $1,024,000. Average annual cost of the project is estimated to be $104,500.

The total annual benefits of $266,000 and costs of $104,500 yield a benefit/cost ratio of 2.54.

First cost of construction summarizes entire costs applicable to facility. This note applies throughout for reservoir projects.

The project may include the mining site of the Paul C. Miller Company, a small sand and gravel producing firm. Their loss of production by inundation or otherwise would have little effect on the area's sand and gravel industry. The processing equipment is portable; thus the operator can vacate the site quickly at little expense.

One rural road at most would be abandoned and a few homes would be relocated or abandoned.

Table III-25

SUMMARY OF DATA ON RESERVOIR SITE 16
(Ravenna)

GENERAL	
Stream	Crockery Creek
River mile	16
Drainage area (square miles)	46
ELEVATION (feet above mean sea level)	
Top of dam	685
Maximum pool	680
Top flood control pool	N/A
Top water supply and water quality pool	680
Top recreation and fish and wildlife pool	679
Stream bed	645
STORAGE (acre feet)	5,800
Flood control	N/A
Water quality	450
Recreation and fish and wildlife	5,350
SURFACE AREA (acres)	
Maximum pool	392
Top flood control pool	N/A
Top water quality pool	392
Top recreation and fish and wildlife	375
PERIMETER	
Perimeter of maximum pool (miles)	10
DESIGN DATA	
Length of dam	990
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	2-15X30
Crest elevation (feet above mean sea level)	665
Apron elevation (feet above mean sea level)	645
Discharge at maximum pool (cubic feet per second)	12,300
ECONOMIC DATA	
Average annual benefits:	
Recreation	$232,000
Fish and wildlife	19,000
Irrigation	15,000
Total	266,000
Average annual cost	104,500
Benefit/cost ratio	2.54

b. Labarge Reservoir. The Thornapple River has the second largest tributary drainage area within the Grand River Basin; the Maple River Drainage area being larger. The Thornapple rises about 5 miles northeast of the city of Charlotte in the central part of Eaton County. From there it flows in a meandering westerly course through Nashville and Hastings. At the latter village, the stream turns northwest, then north and joins the Grand River at the city of Ada. The actual path of the stream is 76 river miles long.

The dam of the proposed Labarge Reservoir, Site No. 22, would be situated on the Thornapple River about 16 river miles upstream of its confluence with the Grand River in Caledonia Township, Kent County. The drainage area of the Thornapple River at the site of the proposed dam is 800 square miles. This area is undulatory and hilly; the smaller tributary streams slope 4 feet per mile, on the average. The runoff from the watershed is the largest and most stable in the Grand River Basin. The soils are glacial drift (silty loam) and in general the watershed is intensively farmed. There are several municipalities along the Thornapple but overall the population is sparse.

The reservoir would include a 2,113 foot long earthen dam constructed across the Thornapple to a height of 63 feet above the stream bed at elevation 740 feet above mean sea level. The water impoundment would extend upstream, on the Thornapple, to a point 1.5 miles east of the village of Irving. Along the Coldwater River, the impoundment would extend upstream to just east of Freeport. The Labarge Reservoir would contain 80,000 acre-feet of water with a surface area of 5,700 acres at a maximum pool elevation of 735 feet. The shore line encompassing the pool would be 42 miles long.

Under usual conditions, in the absence of floods, the water level at the dam would be at elevation 710 feet. This would create a pool, with a volume of 10,000 acre-feet of water. The surface area would be 10,000 acres with the average pool depth being 10 feet and the encompassing shore line being 25 miles long.

The Labarge Reservoir dam would have a spillway 288 feet long equipped with five 20 x 50 foot tainter gates and one 20 x 20 foot tainter

gate. The six gates could pass a discharge of 95,200 cubic feet per second.

Data pertaining to pool elevation, storage volume, and surface area are presented in Table III-26. A plan and features of the dam are presented on Plates Q-55 and Q-56.

The site is located on a stream which the Fish Division of the Michigan Department of Natural Resources has indicated to have potential for an anadramous fish program. However, many streams in the Basin have potential for this program. The stream has not been designated, to date, as part of the anadramous fish program of the Michigan Department of Natural Resources. The availability of a sufficient number of other locations for this purpose resulted in agreement by the Basin Plan Formulation Subcommittee that this site should be considered in more detail as part of the Basin Plan.

That part of the reservoir lying along the Thornapple River, south of Labarge, would flood several rural roads, 5.6 miles of present Penn Central railroad tracks, 2.6 miles of existing 6" pipe for petroleum and several homes at Middleville. Thus substantial relocations would have to be effected. That part of the reservoir lying along the Coldwater River east of Labarge would inundate uninhabited low lands along the stream.

The reservoir would be used for flood control and for fish and wildlife. Flood control benefits would be realized for Plainfield Township and Grand Rapids.

It is estimated that the average annual benefits would be: for flood control $200,000 and for fish and wildlife $42,000. The first cost of construction is estimated to be $5,475,000. Average annual costs for the project are estimated to be $269,200. The total average annual benefits of $242,000 and total average annual costs of $269,200 yield a benefit/cost ratio of 0.90.

Table III-26

SUMMARY OF DATA ON RESERVOIR SITE 22
(Labarge)

GENERAL	
Stream	Thornapple River
River mile	11
Drainage area (square miles)	768
ELEVATION (feet above mean sea level)	
Top of dam	740
Maximum pool	735
Top flood control pool	735
Top water quality pool	N/A
Top recreation and fish and wildlife pool	N/A
Stream bed	671
STORAGE (acre feet)	80,000
Flood control	80,000
Water quality	N/A
Recreation and fish and wildlife	N/A
SURFACE AREA (acres)	
Maximum pool	5,700
Top flood control pool	5,700
Top water quality pool	N/A
Top recreation and fish and wildlife	N/A
PERIMETER	
Perimeter of maximum pool (miles)	49
DESIGN DATA	
Length of dam	1,950
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	5-20X50 1-20X20-Tainter
Crest elevation (feet above mean sea level)	715
Apron elevation (feet above mean sea level)	661
Discharge at maximum pool (cubic feet per second)	95,200
ECONOMIC DATA	
Average annual benefits:	
Flood control	$200,000
Fish and wildlife	42,000
Total	242,000
Average annual cost	269,200
Benefit/cost ratio	0.90

c. <u>Duck Creek Reservoir</u>. The dam for the proposed Duck Creek Reservoir, Site No. 25, would be constructed on the Creek about 3 river miles east of its confluence with the Coldwater River near the village of Freeport. The Coldwater River is the principal tributary of the Thornapple River. The dam would be located in Campbell Township, Ionia County. The proposed impoundment extends northeast about 7 miles from the dam past the community of Campbell Corners. State Highway M-45 crosses through the center of the proposed impoundment in a north-south direction and several other county roads cross the proposed impoundment. The Chesapeake and Ohio Railroad crosses the upper end of the pool.

The land is rolling and hilly and is used mainly for agriculture; there are large wood lots adjacent to the creeks. The soils are loam, clayloam and silty clayloam, all products of glaciation and imperfectly drained. Population in the small region of and around the reservoir is sparse; there are no large villages or cities in the locale.

The proposed Duck Creek Reservoir would be used to impound water on the Creek for recreation and fish and wildlife needs. The reservoir would have a 3,070 foot long earthen dam constructed across the Creek to elevation 825 which would be 55 feet above the stream bed. The water impoundment would extend upstream about 6 miles. The reservoir would contain 19,500 acre-feet of water and would have a surface area of 940 acres at its maximum pool elevation of 820 feet. The average pool depth of the reservoir would be 20.8 feet. At the maximum pool elevation, the perimeter of the shoreline encompassing the reservoir would be about 16 miles.

The dam would have a spillway 33 feet long equipped with a 20 x 30 foot tainter gate that could pass a discharge of 9,200 cubic feet per second. Data pertaining to pool elevation, storage volume, and surface area are presented in Table III-27. A plan of the reservoir and features of the dam are shown on Plates Q-57 and Q-58.

Filling of the reservoir would flood six homes, 0.2 of a mile of the Chesapeake and Ohio railroad track and the following paved highways: Bell, Campbell, Morrison Lake, and M-50. Thus substantial relocations are required.

Average annual benefits from recreation are estimated to be $542,000; for fish and wildlife accommodation the average annual benefits are estimated to be $38,000. The first cost of construction is estimated to be $2,961,000. Average annual cost is estimated to be $448,500. The total average annual benefits of $580,000 and total average annual costs of $448,500 yield a benefit/cost ratio of 1.29.

Table III-27

SUMMARY OF DATA ON RESERVOIR SITE 25
(Duck Creek)

GENERAL	
Stream	Duck Creek
River mile	4
Drainage area (square miles)	26
ELEVATION (feet above mean sea level)	
Top of dam	825
Maximum pool	820
Top flood control pool	N/A
Top water quality pool	820
Top recreation and fish and wildlife pool	N/A
Stream bed	770
STORAGE (acre feet)	19,480
Flood control	0
Water quality	0
Recreation and fish and wildlife	19,480
SURFACE AREA (acres)	
Maximum pool	945
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	945
PERIMETER	
Perimeter of maximum pool (miles)	17
DESIGN DATA	
Length of dam	3,070
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	1-20X30
Crest elevation (feet above mean sea level)	800
Apron elevation (feet above mean sea level)	760
Discharge at maximum pool (cubic feet per second)	9,200
ECONOMIC DATA	
Average annual benefits	
Recreation	$542,000
Fish and wildlife	38,000
Total	580,000
Average annual cost	448,500
Benefit/cost ratio	1.29

d. Fish Creek Reservoir. Fish Creek rises in Crystal Township, Montcalm County. The stream flows from this point south 13 miles, and east 1.5 miles to its confluence with the Maple River. This is where the Maple crosses the east Ionia County Line at the village of Matherton. The proposed dam for the Fish Creek Reservoir, Site No. 47A, would be situated across the stream, 4.5 miles north of its confluence with the Maple in Bloomer Township, Montcalm County, 2.5 miles north of the village of Hubbardston. Upstream from the proposed dam Fish Creek drains 150 square miles. The water course has a well defined valley within the proposed flooding area and is surrounded by moderately hilly country. Most of the land is used for woodlands; there is some agricultural usage and minor urban use at Carson City. Population is sparse in the reservoir locale. The soil is sandy silt with some clay. For the core of the dam there is sufficient clay nearby and furthermore it appears that there is enough clay in the area of the reservoir to limit water seepage to an acceptable level.

The proposed reservoir would be used to impound water for recreation and fish and wildlife needs. The reservoir would have a 4,040 foot long earthen dam constructed across Fish Creek to elevation 755 which would be 60 feet above the stream bed. The reservoir would contain 33,600 acre-feet of water having a surface area of 3,200 acres at a maximum pool elevation of 750 feet. The average pool depth of the reservoir would be 10.5 feet. For the maximum pool elevation of 750 feet, the shoreline encompassing it would be about 27 miles long. It is estimated that under average conditions the reservoir would fill in one year.

The proposed impoundment would extend north through Bloomer Township past Carson City into Montcalm County. At Carson City levees would be required north beyond a smaller tributary, Butternut Creek, roughly to the township line. The reservoir crosses State Highway M-57, an east-west route. Paved roads that would be inundated are: Mt. Hope, Herrick, Boyer, and Garlock. State Highway M-57 would require one new bridge and 0.7 mile of new highway. The Grand Trunk Western Railroad

tracks would be flooded for a distance of 0.4 mile necessitating bridging or rerouting.

This project may lie over the limits of a producing oilfield. Producing and discontinued wells should be located and checked to ensure against pollution by seepage from wells or loss of surface water into abandoned wells.

Data concerning the improvement are presented in Table III-28. A plan of the reservoir and features of the dam are shown on Plates Q-59 and Q-60 respectively.

It is estimated that the average annual recreation benefits will be $841,000; fish and wildlife average annual benefits will yield $115,000 making a total of $956,000. The first cost of construction is estimated to be $5,500,000. Average annual costs are estimated to be $706,100. The total average annual benefits of $956,000 and average annual costs of $706,100 yield a benefit/cost ratio of 1.35.

Table III-28

SUMMARY OF DATA ON RESERVOIR SITE 47A
(Fish Creek)

GENERAL	
Stream	Fish Creek
River mile	7
Drainage area (square miles)	150
ELEVATION (feet above mean sea level)	
Top of dam	755
Maximum pool	750
Top flood control pool	N/A
Top water quality pool	750
Top recreation and fish and wildlife pool	N/A
Stream bed	695
STORAGE (acre feet)	33,576
Flood control	0
Water quality	0
Recreation and fish and wildlife	33,576
SURFACE AREA (acres)	
Maximum pool	3,006
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	3,006
PERIMETER	
Perimeter of maximum pool (miles)	27
DESIGN DATA	
Length of dam	4,000
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	N/A
Crest elevation (feet above mean sea level)	730
Apron elevation (feet above mean sea level)	685
Discharge at maximum pool (cubic feet per second)	27,000
ECONOMIC DATA	
Average annual benefits:	
Recreation	$841,000
Fish and wildlife	115,000
Total	956,000
Average annual cost	706,100
Benefit/cost ratio	1.35

e. Lookingglass River Reservoir. The proposed Lookingglass River Reservoir, Site No. 148, would be located on the upper reach of the Lookingglass River about 3.5 miles southeast of the village of Morrice in the south central part of Shiawassee County. The drainage area of the Lookingglass River above the proposed reservoir site is 15.2 square miles. The area lies within the Southern Michigan drift plains which contains many depressions. The soils consist of shallow and deep mucks, sand, gravel, loams, and clay loams. The topography is hilly and marshy and the area is very sparsely populated.

The proposed reservoir would provide for recreation and for fish and wildlife needs. It would include a 1,300 foot long earthen dam constructed on the river to a height of 22 feet above the stream bed at elevation 875. The dam would include a spillway having one 10 x 25 foot tainter gate that could pass a discharge of 5,850 cubic feet per second. The reservoir would have a storage capacity of 2,500 acre-feet of water that would have a surface area of 400 acres. A plan of the reservoir and features of the dam are shown on Plates Q-61 and Q-62 respectively. Data pertaining to pool elevation, storage volume and surface area are presented in Table III-29.

The total first cost of the proposed reservoir project is estimated to be $4,071,000. Total average annual costs are $184,400 and total average annual benefits are $352,000 which yield a benefit/cost ratio of 1.91.

f. Grub Creek Reservoir. The proposed Grub Creek Reservoir, Site No. 149 would be constructed on Grub Creek, a small tributary of the Lookingglass River. The reservoir site would be located in Antrim Township, Shiawassee County about 2.5 miles east of the village of Morrice. The drainage area of Grub Creek above the site of the proposed reservoir is 9.8 square miles. The topography of the area consists of hills and marshes. The soils are made up of shallow and deep muck, sand, gravel, loams, and clay loams. The area is very sparsely populated.

The proposed reservoir would be used to impound water for recreation and for fish and wildlife purposes. It would have a 1,240 foot long earthen dam on the creek constructed to a height of 28 feet above the stream bed at elevation 874. The dam would include a spillway having one 10 x 30 foot tainter gate that could pass a discharge of 3,920 cubic feet per second. The reservoir would have a storage capacity of 3,670 acre-feet of water having a surface area of 530 acres.

The proposed structure, if constructed at the site currently selected, may conflict with the operations of two local sand and gravel producers, the Fuoss Gravel Company and the Shenk Gravel Company. Data pertaining to pool elevation, storage volume and surface area are presented in Table III-30. A plan of the reservoir and features of the dam are shown on Plates Q-63 and Q-64 respectively. Estimates place the average annual benefits that will result from fish and wildlife activities and recreation at $21,000 and $468,000 respectively. The total first cost of the proposed reservoir structure is estimated to be $5,132,300; the total average annual costs are $252,300. The total average annual benefits are $489,000 which yield a benefit/cost ratio of 1.94.

Table III-29

SUMMARY OF DATA ON RESERVOIR SITE 148
(Lookingglass River)

GENERAL	
Stream	Lookingglass River
River mile	45
Drainage area (square miles)	15
ELEVATION (feet above mean sea level)	
Top of dam	875
Maximum pool	870
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife pool	870
Stream bed	853
STORAGE (acre feet)	2,500
Flood control	0
Water quality	0
Recreation and fish and wildlife	2,500
SURFACE AREA (acres)	
Maximum pool	400
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	400
PERIMETER	
Perimeter of maximum pool (miles)	6
DESIGN DATA	
Length of dam	1,300
Side slopes (horizontal/vertical)	upstream 3:1; downstream 2.5:1
Gates, number and size (feet)	2-10X25-Tainter
Crest elevation (feet above mean sea level)	860
Apron elevation (feet above mean sea level)	848
Discharge at maximum pool (cubic feet per second)	5,850
ECONOMIC DATA	
Average annual benefits:	
Recreation	$335,000
Fish and wildlife	17,000
Total	352,000
Average annual cost	184,400
Benefit/cost ratio	1.91

Table III-30

SUMMARY OF DATA ON RESERVOIR SITE 149
(Grub Creek)

GENERAL	
Stream	Grub Creek
River mile	2
Drainage area (square miles)	10
ELEVATION (feet above mean sea level)	
Top of dam	874
Maximum pool	870
Top flood control pool	N/A
Top water quality pool	870
Top recreation and fish and wildlife pool	870
Stream bed	847
STORAGE (acre feet)	3,670
Flood control	0
Water quality	0
Recreation and fish and wildlife	3,670
SURFACE AREA (acres)	
Maximum pool	530
Top flood control pool	N/A
Top water quality pool	N/A
Top recreation and fish and wildlife	530
PERIMETER	
Perimeter of maximum pool (miles)	9
DESIGN DATA	
Length of dam	1,240
Side slopes (horizontal/vertical)	upstream 3:1, downstream 2.5:1
Gates, number and size (feet)	1-10X30
Crest elevation (feet above mean sea level)	860
Apron elevation (feet above mean sea level)	842
Discharge at maximum pool (cubic feet per second)	3,920
ECONOMIC DATA	
Average annual benefits:	
Recreation	$468,000
Fish and wildlife	21,000
Total	489,000
Average annual cost	252,300
Benefit/cost ratio	1.94

13. Suggested Management Programs.

a. Land Treatment. Land treatment measures for watershed protection will be needed on 1,471,000 acres of crop, pasture, forest, and miscellaneous land within the Basin by 1985. In order to help meet these needs, it is recommended that the current Soil Conservation Service programs and the cooperative Federal-State forestry programs be continued at the present levels of accomplishment. These programs will provide adequate treatment for 145,000 acres of cropland, 15,000 acres of pasture land, 20,000 acres of forest land, and 3,000 acres of miscellaneous land. This represents a total of 183,000 acres, or 12 percent of the total 1985 needs.

In order to more fully meet total 1985 needs, and to provide adequate protection for proposed structural measures, a 10 year accelerated land treatment program is recommended. This program will apply the necessary treatment on an estimated 481,200 acres, or 33 percent of the total Basin needs. The cost of this program is estimated to be $26,355,600. One portion of this accelerated program will be implemented within the proposed upstream watershed areas, (refer to page III-35). This program will provide adequate treatment for 148,600 acres at an estimated cost of $7,763,000 (Table III-30). It will accomplish 74 percent of the remaining 1985 needs within these watersheds.

The other phase of the accelerated land treatment program will be applied within the drainage area of the proposed multi-purpose structures. This program, to be implemented through Soil Conservation Service and Cooperative Federal-State forestry programs, will provide adequate treatment for 332,600 acres at an estimated cost of $18,572,000. It will provide for 66 percent of the remaining 1985 needs behind the proposed structure sites.

Conservation treatment measures will include (1) water control measures such as terraces, waterways, and field diversions; (2) measures to protect the soil from erosion and increase infiltration rates such as strip cropping, contouring, cover cropping, minimum tillage, and crop residue management; (3) farm drainage systems; (4) farm ponds; (5) gully control measures; and (6) improved forest land management.

Table III-31 Recommended 10-year Accelerated Land Treatment to be Applied by 1985

Grand River Basin, Michigan

Land Use	Land Treatment Acreage and Installation Cost 1/ — Within Potential Small Watersheds		Behind Potential Multiple-Purpose Structures		Total		Remaining Area in Basin Needing Treatment
	(Acres)	(Dollars)	(Acres)	(Dollars)	(Acres)	(Dollars)	(Acres)
Cropland	107,600	5,664,300	255,000	12,529,000	362,600	18,193,300	240,400
Pasture Land	20,000	689,500	27,300	1,401,900	47,300	2,091,400	86,700
Forest Land	12,600	192,200	33,900	1,391,600	46,500	1,583,800	404,500
Miscellaneous	8,400	225,800	16,400	520,100	24,800	745,900	75,200
Subtotal	148,600	6,771,800	332,600	15,842,600	481,200	22,614,400	806,800
Technical Assistance Cost							
Soil Conservation Service		800,000		1,734,000		2,534,000	
Federal-State Co operative Forestry		191,700		995,500		1,187,200	
Total Cost		7,763,500		18,572,100		26,335,600	

1/ Price Base - 1967; includes multiple treatment of these acres.

Table III-32 ACCOMPLISHMENT OF LAND TREATMENT NEEDS

Grand River Basin, Michigan

Land Use	Area Requiring Treatment By 1985	Proposed Early Action Program 1/	Remaining Needs After Treatment 1985	2000	2020
		(1000 Acres)			
Cropland	748.0	507.6	240.4	100.0	60.0
Pasture Land	149.0	62.3	86.7	35.0	25.0
Forest Land	471.0	66.5	404.5	284.0	25.0
Miscellaneous Land	103.0	27.8	75.2	18.0	15.0
Total	1,471.0	664.2	806.8	299.3	125.0

1/ Estimated accomplishments of both current and accelerated programs.

The combined area and cost of land treatment to be applied by this proposed accelerated program within the upstream watershed and behind the multi-purpose structures is presented in Table III-30.

To provide additional incentive for accomplishment of the proposed forestry program, it is recommended that the Federal Government cost-share 80 percent of both the technical assistance costs with the State and the installation costs with private landowners. This may require additional authorization and new cooperative agreements between State and Federal Governments.

Accomplishment of the current and proposed accelerated land treatment programs described above will apply needed conservation and improvement measures to 45 percent of the problem area by 1985. The remaining land treatment needs (Table III-31) will be considered for corrective measures through a continuation of effort under current programs with acceleration if necessary. Approximately 90 percent of all land treatment needs should be satisfied by the year 2020. A portion of these land improvements will be installed in conjunction with the 28 upstream watersheds with potential for future development discussed in the structural phase of this section.

b. Soil Erosion Control Regulations. Soil transport to lakes and streams becomes a more critical problem each year due to intensive farming practices, inadequate land conservation practices, and uncontrolled runoff from rapidly urbanizing areas. Sedimentation in waterways leads to increased flooding, destruction of feed areas for fish, hazardous conditions affecting recreational uses of streams, and adverse changes in water quality characteristics. In particular, regulations to enforce erosion control measures at constructive sites are needed. Land treatment programs should be implemented. New State and local legislation, to supplement existing authorities, is essential if the Basin's soil resources and water courses are to be protected.

c. Water Supply Improvement. Ground and surface water development provide significant alternatives to reservoir storage development for the creation and maintenance of municipal or industrial water supplies. This is particularly true in the western part of the Basin where pipelines to Lake Michigan may be shared by several communities, or where ground water aquifers are abundant and may support enough wells to serve an entire regional system.

The development of artificial underground aquifers and the greater use of natural aquifers may be other feasible alternatives to reservoir storage. Best results can be expected in those areas where the permeability of thickness of overburden is such that adequate infiltration rates can be achieved. Diverting streams through such areas or creating natural pools, as the city of Kalamazoo has done, may be other acceptable alternatives. Wells drilled in close proximity to these areas of improved water infiltration and retention or along streams might withstand higher pumping rates than wells in locations lacking access to such ground water supplies. Water supply options such as these may be profitably employed in many Basin areas, and their use may well be needed in those areas without adequate reservoir sites.

d. Stream Channel Clearance.* Stream channel clearance pertains to the removal of any obstruction in the stream channel that is detrimental to the public health, safety, or welfare. Pilings and other abandoned structures are known to exist in the Grand River and the Thornapple River. Dislocated trees are scattered along the stream beds, and pile up at bridge abutments and dams. Minor streams are sometimes completely bridged by obstructions.

In order to preserve the streams and to develop them for maximum effectiveness, local governmental units should adopt and enforce waterway regulations requiring that obstructions detrimental to the public health, safety, or welfare be designated as public nuisances and be eliminated. Whenever possible, responsibility for the prevention or elimination of a public nuisance should be assigned, with appropriate penalties against failure to act, but each local governmental unit should be prepared to eliminate the nuisance if it is not possible to identify the responsible party.

14. Suggested Data Collection Programs.

a. Horizontal and Vertical Geodetic Control. The greater part of the Grand River basin is without horizontal geodetic control; however, the basin is covered

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* The Corps of Engineers, under provisions of Section 208 of the 1954 Flood Control Act (Public Law 83-780) may perform certain clearing and snagging operations where obstructions to stream flow cause severe flooding conditions.

by a general network of vertical geodetic control. There is a limited amount of horizontal control around the outer edge of the basin. Plans should be made and funds provided to cover the basin with a network of horizontal control. The possible need for a more comprehensive vertical control network over the area should also be considered. Such a network of horizontal and vertical geodetic control would be valuable in planning construction, actual construction, road relocations, and acquisition and land use within the basin.

b. Topographic Mapping. Existing topographic mapping of the Grand River basin is inadequate. As of 30 June 1970, about 550 square miles of the Basin had never been mapped for topographic features. Within the past five years, an active mapping program within the Basin has overcome some of the deficiency. Work is underway in those quadrangles which are still unmapped. Continuation of this program, which includes updating and conversion of 15-minute quadrangles to 7-1/2 minute quadrangles with 5-foot contour intervals, would greatly aid in the planning and development of resources within the Grand River basin.

c. Soil Surveys. Soil surveys have been used to guide land use and management decisions on farms and in forests for many years. These same principles of managing soil and water can be applied to urban development problems. The soil survey describes soil limitations for building sites, on-site sewage disposal, road construction, recreation development, and other uses. It may also be used to locate potential sediment source areas, and as a tool for flood plain delineation.

Completed and currently programmed soil surveys cover eleven of the twenty counties with acreage within the Basin. The Soil Conservation Service is conducting soil surveys for conservation planning in the remaining nine counties. This level of survey activity will not be sufficient to provide for all of the needs of the expanding urban areas.

An accelerated program is recommended which will complete the soil survey throughout the Basin by 1985. A total area of 1,172,800 acres will be surveyed through the National Cooperative Soil Survey at an estimated total cost of $751,000. Early emphasis should be given to the expanding Grand Rapids and Jackson areas.

Section IV

BENEFITS AND ALTERNATIVES - PLAN A

1. INTRODUCTION

This section identifies the benefits attributable to the Basin Plan by functional category of benefit; for example, water supply, water quality enhancement, irrigation and so forth. It also, where appropriate, identifies and evaluates alternative means of providing benefits, by functional category.

2. WATER SUPPLY

a. General. Data on municipal and municipally supplied industrial water use was presented in Section II.

b. Water Supply at Lansing. It has been estimated, on the basis of projected water needs relative to data obtained from the Geological Survey, that Lansing will require 118 million gallons of municipal and industrial water by 2020, and that only 90 million gallons per day will be available from ground water sources. The insufficiency (28 million gallons per day) could be made up by reservoir storage.

Development of the Williamston site on the Red Cedar River as a single-purpose water supply reservoir would cost approximately $10,000,000.

An alternative to reservoir construction would be construction of a pipeline from one of the Great Lakes. A connection with Lake Michigan would require the construction of a 60-inch diameter pipeline 80 miles long with 9 pumping stations. Construction cost would be $30,000,000, based on estimated costs of $60 per lineal foot of pipe and $52,000 per pumping station. The cost for the right-of-way would be approximately $5,200,000.

The annual costs of alternative methods of meeting the water supply needs of the Lansing area are presented in Table IV-1.

3. LAND RESOURCES

a. Agricultural and Upstream Watershed Structural Developments. The fourteen watershed projects proposed for early development would include the following works of improvement: 208 miles of multiple-purpose (flood control and drainage) channel improvement; two multiple-purpose flood prevention and recreational structures; and one single-purpose reservoir for fish and wildlife. Because of the long range notice of the need, the selections of an alternative can be deferred.

TABLE IV-1 SUMMARY OF WATER SUPPLY ALTERNATIVES AT LANSING
(All costs in 1967 dollars)

Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O&M Cost	Total Annual Cost (Adjusted to 1970)
Storage Reservoir (46,000 acre-feet)	2000	$10,000,000	$2,600,000 (4-5/8%)	$130,000 (50 yrs at 4-5/8%)	$46,000	$180,000
Pipeline to Lake Michigan	2000	$30,000,000	$7,700,000 (4-5/8%)	$400,000 (50 yrs at 4-5/8%)	$250,000	$650,000

The structural measures would benefit a total area of 71,400 acres through reduced flooding and improved agricultural drainage. Total damages within the fourteen watersheds would be reduced by 87 percent. Timely removal of excess water contributes to: (1) reduced cost of production, (2) improved crop quality, (3) increased crop production, and (4) encourages a shift of crop production from upland areas not well suited to cultivation.

The total annual cost of the structural measures is $1,267,100. Annual benefits would be $2,723,700.

b. Land Treatment. The land treatment program would provide adequate treatment for 664,000 acres of land in the Basin. Current programs will provide treatment for 183,000 acres. The remaining 481,200 acres would be treated through accelerated programs within the proposed upstream watersheds and behind the proposed multiple-purpose structures.

Current land treatment programs would provide adequate treatment for 145,000 acres of cropland, 15,000 acres of pasture land, 20,000 acres of forest land, and 3,000 acres of miscellaneous land. The total of 183,000 acres represents 12 percent of the total 1985 needs.

Within the upstream watershed areas, the accelerated program would provide adequate treatment for 148,600 acres. All of the cropland needing treatment - 107,600 acres - would be treated. Twenty-three thousand acres of pasture land need treatment, of which 87 percent would be treated. Fifty-three thousand four hundred acres of forest land need treatment, of which 24 percent would be treated. Seventeen thousand acres of miscellaneous land need treatment, of which 50 percent would be treated. This program would accomplish 74 percent of the total 1985 needs within the upstream watersheds.

Within the drainage area of the multiple-purpose structures, the accelerated land treatment program would provide adequate treatment for 332,600 acres. All of the cropland needing treatment - 255,000 acres - would be treated. Fifty-one thousand acres of pasture land needs treatment, of which 54 percent would be treated. One hundred fifty-six thousand seven hundred acres of forest land need treatment, of which 22 percent

would be treated. Forty thousand acres of miscellaneous land need treatment, of which 41 percent would be treated. This program would accomplish 66 percent of the total 1985 needs within the drainage area of multiple-purpose structures.

Some of the effects of the non-structural program are physical and biological. Surface runoff and erosion rates would be substantially reduced, preventing the movement of approximately 500,000 tons of soil annually. Reduced sediment yields would improve water quality, prevent damage to downstream developments, and extend the life of reservoirs. Fish and wildlife habitat would also benefit through reduced sediment encroachment and deposition.

Other effects would be primarily aesthetic. The conservation of forest land and the establishment of tree and plant cover in urban and suburban areas would provide an environment with open areas of natural beauty. Such areas would provide welcome visual contrasts to the maze of man-made structures. They would also help to dampen harsh city noises, and purify the air of pollutants while replenishing the atmosphere with oxygen.

Complete soil surveys would encourage the use of accurate up-to-date soils information in connection with land use decisions. Thus land use and development could be planned to take advantage of natural soil characteristics with full knowledge of the limitations for various purposes.

c. Reduction in Damage. Although the flood plains in the Grand River basin are generally narrow and not actively farmed, flood damage frequently does occur to the agricultural sector. Most of the damage is of a combined nature emanating from inadequate existing channel depth or capacity and very flat topographic features.

Damage due to flooding and impaired drainage occurs primarily during the spring through inundation of crops and planting delays. Excessive soil moisture due to flooding and lack of adequate drainage outlets also occurs during summer and at harvest time. This condition increases cultivation and harvesting costs, adversely affects the quality of some crops, and depresses crop yields.

The fourteen watershed projects proposed for completion by 1985 and an accompanying program of land treatment and management to control erosion and sediment problems will make significant reductions in damages from excess water on agricultural and forest land.

Average annual damages in the basin from excess water due to flooding or inadequate drainage amount to $3,550,000. The proposed plan of development to be implemented in the next 10-15 years is estimated to reduce damages by $938,300 or 26 percent.

The 26 watershed projects proposed for completion following 1985 are intended to provide protection from flooding and inadequate drainage on an additional 62,000 acres. However, at this time most of the land within these projects is committed to uses other than crop production.

d. Improvements in Efficiencies. Increased efficiency in the production of agricultural commodities is possible through the combined effects of land treatment, flood prevention, agricultural drainage and irrigation. While additional water resource development is not required to meet future production objectives in the Basin it can contribute to efficiency of production, by reducing (1) crop losses, (2) the total on-farm cost of production, and (3) the acreage required to meet production objectives.

It should be noted that the process of water resource and related land development tends to enhance the productive capabilities of the resources that are developed. In the development process certain of these resources become more efficient in producing the Basin's output and in turn cause marginal land resources to shift out of production if additional output is not required. A portion of the overall cost savings due to development may be passed on to the consumer in lower food prices but a substantial share may be retained in the agricultural sector as improved incomes to those who can take advantage of the development opportunities. The total annual on-farm costs of meeting projected major crop production requirements without further resources developments are: 1985 - $36.3 million; 2000 - $50 million; and 2020 - $68.3 million (Table IV-2). With resource development investment applied up to the level of full economic potential, these on-farm production costs

TABLE IV-2 Projected annual on-farm cost of producing major crops without additional resource development and comparisons between full economic potential and 14 proposed projects, Grand River Basin 1985, 2000, and 2020

Development Level	1985	2000	2020
	(1000 Dollars) 1/		
Without additional resource development	36,318	50,047	68,296
With full economic development potential	33,653	48,019	66,588
With 14 proposed projects for Early Action	35,506	48,708	66,914
Savings in production costs with full economic development potential	2,665	2,028	1,708
Savings in production costs with 14 proposed projects	812	1,339	1,382

Source: Economic Research Service study of economic impacts associated with USDA proposed plan.

1/ 1964 constant dollars

can be reduced to: 1985 - $33.7 million; 2000 - $48 million; and 2020 - $66.6 million. This represents a reduction of nearly 2.7, 2.0, and 1.7 million dollars in the respective time periods. The decline in potential cost efficiencies from water resources development over time reflects a relaxation of certain production constraints in the analytical model in the more distant time periods. These constraints to full efficiency were imposed in the earlier time periods to simulate farmers' tendencies to utilize the agricultural investments already committed within the Grand River basin. In the long run such barriers to the free flow of productive resources are less restrictive and other areas outside the Basin, notably the Thumb area of Michigan, are better able to compete. Consequently, such considerations have a negative influence on the development potentials within the Basin.

Not all the land that could be most efficiently developed in the Basin lies within the feasible projects being proposed for installation by 1985. Annual cost reductions that appear possible on developed acreage within the early action program areas amount to $812,000 by 1985, $1.3 million by 2000, and $1.4 million by 2020. As the evaluation period extends into the future, development within the fourteen proposed projects approaches the total economic potential for development.

Beyond 1985 the additional 26 projects would bring new land into production which would compete with available cropland that has a development potential. Estimating the potential cost reductions from these projects is hazardous. If the annual costs of production, land clearing, and development are by some chance less than production costs on marginal land, then these new acres will replace them in production and contribute to savings. But the displacement of developed acreage in the 14 projects is also possible. At this point the potential for additional development beyond the level proposed for 1985 appears to be limited.

This analysis, however, was based solely upon the proposed agricultural program and does not consider the effects of other aspects of the overall plan of development. To the extent that these aspects would reduce the agricultural resource base beyond that considered in the agricultural studies the economic opportunities for further resource development would be enhanced and would justify expansion of the program here proposed.

e. Agricultural and Forest Production and Stabilization. Projected demands for agricultural production in 1985 from the Basin call for 2.9 million tons of feed crops, 0.4 million tons of food crops, and 0.3 million tons of specialty crops. Feed crops consist of feed grains and roughages (corn, oats, barley, corn silage, pasture, and hay). Food crops include wheat, soybeans, dry field beans, and potatoes while specialty crops are composed of a large variety of vegetable crops, tree fruits, and berries. With no additional flood protection, irrigation, or drainage development, the 1985 production requirements can be met on 1,095,700 acres of crop land and pasture (Table IV-3). For the year 2000, demands for feed crops increase to 3.8 million tons, food crops to 0.8 million tons, and specialty crops to 0.4 million tons, all of which can be produced on 1,392,500 acres of crop land and pasture without further resource development. Projected requirements for the year 2020 amount to 5.3 million tons of specialty crops. This production objective requires 1,589,200 acres of cropland and pasture in the absence of further resource development.

Projected demands for forest products in 1980 call for the cutting of 7.0 million cubic feet of timber from nearly 644,000 acres of forest land. Timber products generally include saw logs, veneer logs, minor industrial products such as piling and posts, and pulpwood. For the year 2000, forest product demand reaches 9.8 million cubic feet, and by 2020, the volume is projected to be 12.8 million cubic feet. Forest land requirements to produce these products reach a high of 735,000 acres in 2000 and decline to about 699,000 acres by 2020 due to rising trends in growth rates.

Under the same production requirements, but considering the alternative of water resource development, the projected demands could be met on fewer more intensively managed acres. This analysis indicated that under full economic development the projected production requirements could be met on the following acreages of crop and pasture land: 1985 - 993,100 acres; 2000 - 1,326,600 acres; and 2020 - 1,463,300 acres. Associated with this irrigation and drainage development efficiency is the idling

TABLE IV-3 Projected acreage required for producing major crops without additional resource development and comparisons between full economic potential and 14 proposed projects, Grand River Basin, 1985, 2000, and 2020

Development level	1985	2000	2020
	(1000 acres)		
Acreage required without additional development	1,095.7	1,392.5	1,589.2
Acreage required with full economic development potential	993.1	1,326.6	1,463.3
Excess acreage with full economic development potential	102.6	65.9	125.9
Acreage required with development only in 14 proposed projects	1,063.4	1,363.7	1,536.1
Excess acreage with development only in 14 proposed projects	32.3	28.8	53.1

Source: Economic Research Service study of economic impacts associated with USDA proposed plan.

of marginal acres that are no longer required to meet anticipated food and fiber needs. These idled marginal acres could be converted to multiple forest and recreational use through revegetation. Intensified land management and treatment of forest land will permit expanded recreational opportunities and improved environmental quality while still meeting forest product requirements on available forest land acreage.

If only the development potential of the proposed fourteen projects is considered, less land would become idle while meeting identical production objectives. In 1985 acreage requirements would be reduced by 32,300 acres, in 2000 by 28,800 acres, and in 2020 by 53,100 acres. Relatively more land is required by 2000 under both full development potential and the proposed development program, so fewer acres are idled than in 1985 and 2020. This is largely due to relatively greater roughage requirements and smaller feed grain requirements than in the other two years. Feed grains are most likely to be grown on those soils that would respond more favorably to development that the soils in roughage production.

Additional development, associated with the 26 proposed projects after 1985, would contribute to the stock of idle acres as well. While the contribution might be significant it is doubtful whether it would exceed one quarter of the remaining potential. It is also conceivable that bringing new land into production might eliminate some existing potential on the current cropland base.

While it is true that idle acres for agricultural purposes are associated with resource development under a given level of agricultural production, it is also true that more acres are available for other uses. These same acres could be used to produce additional agricultural commodities if other areas of the region or nation have higher production costs or are unable to meet their production targets. They may also be needed to replace acres withdrawn for nonagricultural uses at a rate faster than was originally assumed in this analysis.

Water resource development, in addition to providing for greater efficiency of production, has the added advantage of reducing risk and uncertainty and stabilizing production. The vulnerability of agricultural production to climatic hazards is well recognized. All farmers face the problem of fluctuations in yields and production resulting from variations in rainfall as well as the other uncertainties of weather. Those resource owners with flood, drainage, or drought problems experience even greater risk and uncertainty than the average producer. The proposed fourteen projects will have a marked effect on reducing the risk and uncertainty associated with production on the 60,000 acres of cropland involved. As uncertainty is reduced, farmers can manage their resources more efficiently and provide a more stable agricultural economy. With reduction of the risks and uncertainties associated with flooding, drainage, and drought problems, production can be planned at the optimum level with the associated levels of purchased inputs. Losses will be cut to a minimum and production of a more profitable combination of crops with less yield fluctuation will result from better timing of operations. All of this will add greater stability to production levels within the Basin.

f. Income and Employment. Stabilization of agricultural production on cropland within the proposed project areas may have varied effects on income and employment in the Basin. With stability of production comes stability of income, frequently at a higher average annual level. Stabilized income will encourage stabilized expenditures for factors of production and large machinery items rather than encouraging savings from periods of high income to cover anticipated periods of low income. Under normal conditions of moisture uncertainty, major machinery purchases can be made only after a good year due to problems of income and credit availability. The credit position of a farm operator whose income stream is continuous and fairly stable is far superior to that of a farm operator whose income stream reflects wide swings and in some years may even be negative.

Higher incomes and improved credit positions will tend to cause these farm operators to demand more service, purchase more productive inputs for the farm business and seek to expand their farming operations, all of which will have direct favorable income effects on the local business sector. In the process of expanding their farm operations these resource owners will acquire additional land resources, thereby displacing inefficient or marginal operators. The idling of marginal acres in connection with the proposed resource development program has already been discussed. It is an important fact that the marginal acres are not located in some specific area. They are interspersed throughout the Basin and occur to some degree on farms that will continue in production. Agricultural output displaced from these acres by the proposed program will be produced on fewer but more intensively managed acres with additional development. These operators will expand their purchased inputs. Over time they will invest more heavily in new labor saving technology in the form of larger more specialized machinery, pre-mixed feeds, and bulk handling. This along with the idled acreage will reduce the farm labor requirements more rapidly than would occur under a program of no further resource development.

It is rather difficult to evaluate the net effect of the proposed development program upon rural service communities within the Basin. On the one hand farmers on marginal units and unable to compete effectively have good opportunities in the Basin to enter part-time farming, at least in the short run. This allows them to take the first step in occupational migration and effectively removes their land from agricultural production in whole or in part since it contributes to total output at a low level. Marginal operators and part-time farmers do not apply advanced technology as rapidly as others in a more favorable competitive position, preferring to substitute labor for capital, and thus purchase fewer production inputs. To the extent that they remain in the community, using their farms as rural residences while pursuing off-farm employment, they will bring added income to the community through nonfarm purchases. Those that continue to farm on a reduced scale may also provide a ready market for used machinery from local dealers.

On the other hand, shifts in the location of production will take place. Outout that would have been produced on the marginal lands will relocate on the more productive acreage benefiting from water resources development. To the extent that local communities are dependent upon providing the inputs for this production and marketing the commodities produced they will be disadvantaged. Of course, other communities within the Basin would benefit from expanded activity in their area and in effect it would simply amount to an income transfer within the Basin.

Intensified management of forest land will improve the efficiency of existing small woodland ownerships. Where these areas can be expanded through the *natural revegetation or purposeful conversion of marginal crop* and pasture land to productive forest land, otherwise disadvantaged areas will begin to benefit from the increasing sale of forest products, recreation, and other forest amenities and services. In time, the return to these communities from forest products and services may more than account for any loss due to a shifting of agricultural production out of the area. Over the long run, expanded production of forest products and services from the forest management and land treatment program will add significantly to local employment and income. The expanded volume of high quality timber in larger forest units will develop markets for timber products that would not have otherwise existed due to the inefficiencies of harvesting low quality - low yielding stands. Larger volume of higher quality timber will also command improved prices which will further add to the Basin economy.

g. Water Supply Services. The Basin has experienced substantial industrial and population growth and is projected to continue this trend due to its favorable location in southcentral Michigan. Most of this growth has taken place in or near the three major population centers of Grand Rapids, Lansing, and Jackson. Each center has developed adequate water supply services and is expected to maintain and expand them to meet future demands. Large water using industries have also developed their own ground water sources of supply.

Of the new reported industrial development in Michigan during the decade 1957 to 1966, two-thirds were local expansions, one-sixth were new starts, 10 percent came from somewhere else in the State, and 6 percent were from outside Michigan.[1] Future industrial growth will undoubtedly continue to favor locations with existing well-developed facilities and a history of providing essential services. However, some new development is also expected to take place in rural areas where local communities have established satisfactory facilities.

No provision has been made for inclusion of municipal and industrial water storage in feasible small watershed projects in the Basin. These sites are located where adequate water systems are within reasonable distances to municipalities and industries. The U.S.D.A. programs administered through the Farmers Home Administration are, however, ideally suited to assist local communities of 5500 or less in developing their own water supply and sewage treatment facilities. F.H.A. is actively pursuing a program of planning, design, and financial assistance to local communities throughout Michigan.

It is anticipated that future rural farm and nonfarm water supply requirements will be met primarily from ground water sources which are believed to be adequate for this purpose. However, in those locations where local water systems exist or are developed, this service will probably be extended where feasible to the rural population.

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[1] Nanneman, Richard J., Employment Changes in Rural Michigan, Agricultural Economic Report No. 110, Michigan State University, September, 1968.

4. NAVIGATION

a. Improvements Desired

(1) Commercial. Improvements in the interest of commercial navigation have been requested for Grand Haven Harbor and the lower reach of the Grand River up to the Bass River. Deepening of the existing harbor channel from 21 feet to 25 feet and enlarging and deepening the existing turning basin are improvements which local interests have requested for Grand Haven Harbor. According to local interests, the existing project depth of 21 feet prevents the realization of more economical transportation rates available from loading larger, deep-draft vessels to their full capacity. Enlarging the turning basin would provide additional maneuvering space and permit the utilization of larger more economical vessels.

The gravel companies operating in Ottawa County have requested widening and deepening of the Grand River over the existing project up to the mouth of the Bass River. They state that these improvements would permit an increase in transporting capacity with a corresponding economic savings in the movement of sand and gravel by barge by permitting larger barges and an increased number of barges per tow. Widening the channel would also increase safety, especially at bends of the river, in view of the increasing commercial and recreational boat traffic expected in the future. The sand and gravel companies stated that they see no need for extending the improved channel upstream of the Bass River insofar as their commercial applications are concerned.

(2) Recreational. The Waterways Division of the Michigan Department of Natural Resources requested that the following improvements be investigated as to their economic feasibility:

(a) Construct a channel 100 feet wide and five feet deep from the upstream limit of the presently authorized and maintained river channel to Grand Rapids.

(b) Construct a lock at Grand Rapids adequate to handle recreational craft up to 65 feet in length.

(c) Construct a channel 80 feet wide and five feet deep from the site of the proposed lock at Grand Rapids to a point approximately 70 miles from the mouth of the Grand River, at Lowell, and construct a channel 50 feet wide and four feet deep from Lowell, to a point approximately 110 miles from the mouth of the Grand River, at Portland. Where active dams are encountered along this route, provision should be made for portages, except at Grand Rapids, where a lock is deemed to be essential.

(d) Provide additional water areas by impounding the waters of the Grand River and its tributaries in at least two areas, one between Lansing and Portland and the other between Lansing and Jackson. These impoundments would be intended to provide recreational water areas for the residents of the Lansing area and should be designed to permit recreational boating. Each impoundment should provide a minimum water surface acreage of 650 acres. It is considered desirable to plan such impoundments so that

the minimum width of the lake created thereby would be approximately 2,000 feet and the minimum length of the lake one mile. If lakes of 650 acres were provided, a minimum of four miles of shoreline would be available per lake for recreational purposes.

b. Benefits and Alternatives

(1) Commercial - Grand Haven Harbor. Information furnished by local interests and preliminary investigations by the Corps suggest that justification of harbor improvements at Grand Haven may be warranted, pending the results of engineering and economic feasibility studies. Existing harbor facilities, with the limiting project depth and a restricted turning basin, preclude the realization of a savings on transportation costs. If the deep-draft improvements are instituted, as described under "Improvements Desired" above, the vessels calling at the Port of Grand Haven could load to capacity, resulting in a savings due to faster loading and a decreased cost per ton. Information supplied by local commercial interests, and detailed in tables IV-4 and IV-5, shows the economic advantages of increased harbor depth. Table IV-4 projects the economy of faster loading in 1968, 1973, and 1978, based on 1967 tonnages. In addition to a savings per vessel, harbor terminal facilities would be able to handle more vessels per season. Advantages of deeper harbor and channel facilities allowing deeper draft vessels and increased loading capacity are shown in table IV-4. Steamship companies queried by local interests suggest that an average freight savings of 5 percent on sand and gravel cargo revenue for each extra foot of draft below 21 feet to which the vessel can load will accrue with the deepening of the harbor.

Preliminary investigations suggest that the proposed harbor improvements appear justified. They will be further investigated under the existing authorized study adopted 1 March 1950 by the House Public Works Committee.

(2) Commercial - Grand River. Based on the limited information available, widening the existing channel, especially at the bends, and increasing the project depth to 10 feet, from Grand Haven to the upstream project limit at the Bass River, appears to be worthy of further detailed

TABLE IV-4

ECONOMIC SAVINGS IN FREIGHT COSTS

AS A RESULT OF FASTER LOADING*

BASED ON 1967 TONNAGE

(1) Deeper water will allow approximately one hour in time savings during loading for all vessels.

Vessels loaded in 1967 106
Deep-Draft barges loaded in 1967 4

Total deep-draft vessels loaded 110
Total hours that could have been saved 110

Economic savings at $300 per hour based on 1967 tonnage........ $33,000

Economic savings at $300 per hour based on projected tonnage
and 10,000 tons average per boat for 1968....................... $37,000
and 15,000 tons average per boat for 1973...................... $34,800
for 1978...................... $36,900

(2) An increase in loading capacity in tons per hour will result in a definite economic time saving for the vessels involved.

(a) Foundry sand loaded out 1967 616,490 net tons

Total loading time 1967 336 hours

Average tons per hour loaded 1,835

Total loading time based on 3,000-3,500 tons per hour 193 hours

Total hours in loading time to be saved @ 3250 tons per hour
based on 1967 tonnage 143 hours

Economic savings based on 1967 tonnage..................... $42,900

(b) Total hours in loading time to be saved
based on 1968 projected tonnage (745,000 net tons) 174 hours

Economic savings based on 1968 anticipated tonnage........ $52,200

(c) Total hours in loading time to be saved
based on 1973 projected tonnage (1,500,000 net tons) 355 hours

Economic savings based on 1973 anticipated tonnage........ $106,500

(d) Total hours in loading time to be saved
based on 1978 projected tonnage (1,600,000 net tons) 380 hours

Economic savings based on 1978 anticipated tonnage........ $114,000

* Supplied by local interests.

investigation. This channel is used by two sand and gravel companies which ship their raw materials by barge from their workings near the Bass River down to Grand Haven. At the present time the tows consist of two barges and a push tug which make three round trips per day, six days per week. The sixth day is an overtime day necessitated by the fact that the size of the tows is limited by the present channel width. The operators desired to increase the size of the tows by utilizing three barges per tow instead of two. However, this cannot be done under existing channel dimensions, except during periods of high water when the longer tow would be able to extend out beyond the channel lines without danger of grounding. If the channel is widened to permit use of three barge tows at all times, a total of only 12 tows per week would be required to move the present commerce instead of the 18 tows per week now required. Therefore, the resultant benefit would be six less tows per week which would eliminate Saturday overtime and three other tows per week. The commercial users of the river estimate that, should the channel be widened so that the described benefit would be realized, a total economic savings of $298,480 per year could be reasonably predicated as indicated in Table IV-4a. Widening the channel might also provide some benefit to recreational boating by increasing the safety to navigation in this reach of the river which is heavily used by commercial interests.

Widening the river channel from the present 100-foot width to 125 feet in the straight sections and 150 feet at the bends would be sufficient to permit the use of three barge tows at all times. Increased usable channel widths of the Grand River above the railroad bridge are considered necessary to decrease the hazards and restrictions imposed on existing barge traffic and to afford the passage of longer tows in the future. The maneuvering characteristics and related space requirements of the existing and foreseeably longer tows determine the necessary widening.

Deepening of the existing project channel to 10 feet appears warranted inasmuch as the present 8-foot depth precludes the realization of more economical transportation rates available from deeper draft barges.

TABLE IV-4a

Savings* on Sand Transported on Grand River

Between Bass River and Spring Lake

	No Improvement	(total commerce 3,980,000 tons) Improvement - 125-foot channel and project depth 8-Foot	9-Foot	10-Foot
Vessel Operation cost per hour	$ 61	$ 61	$ 61	$ 61
Vessel Time charged to cargo trip, hours	11	11	11	11
Cost per trip	671	671	671	671
Weighted Average cargo per barge, tons	1,200	1,200	1,400	1,600
Number of barges per tow	3	3	3	3
Total cargo per tow	2,400	3,600	4,200	4,800
Trans. cost per ton	0.28	0.19	0.16	0.14
TOTAL COST	$1,114,400	$756,200	$636,800	$557,200
Annual Transportation Savings		$358,200	$477,800	$557,200
Savings per ton		0.090	0.120	0.140
Present worth of annual transportation savings				
1,180,000 @ Savings/ton		$106,200	$141,600	$165,200
2,800,000 @ Savings/ton		$ 85,680	$114,240	$133,280
TOTAL		$191,880	$255,840	$298,480

* Based on 1967 price levels.

Table IV-5 details transportation savings on sand and gravel shipments between Bass River and Spring Lake. Cost estimates assume a 125-foot channel width and show the savings on 8-, 9-, and 10-foot project depths. The cheapest transport cost per ton is realized with a 10-foot deep channel, allowing deeper draft barges and a cost per ton of $0.14. Cost estimates for engineering feasibility and derivable benefits are being made. The project merits further study. There is also no known potential user for a channel for deep-draft commerce on the Grand River upstream of Grand Haven.

(3) Recreational - Bass River to Grand Rapids. The reach of the Grand River extending from Grand Haven to the Bass River, and now covered by the present Federal project, is adequate for existing and prospective recreational boat traffic. The river upstream of the Bass River extending to Grand Rapids was formerly a part of the Federal project, but was abandoned by the 1930 River and Harbor Act. No work has been done on this reach of the Grand River since 1910 when a project providing for a 6-foot deep channel 100 feet wide was completed to Grand Rapids. This project involved the dredging of about 2,800,000 cubic yards of material and the construction of 132,624 linear feet of brush and pile training walls to confine the flow. In the absence of any commercial use of the upper river, the dredged channel above Bass River was not maintained and filled up so that by 1914 the low water depth was as little as 2-1/2 feet in places. It was estimated in 1932 that controlling depths at low water were probably less than 2 feet. The bed of the river in this reach is practically all sand and fine gravel, with clay found at a few points at depths of 10 to 15 feet. The channel width at low water is from 280 to 820 feet, which was narrowed by training walls from 160 to 180 feet in places. The training walls are for the most part washed out or buried in sand bars.

Preliminary estimates, based on available data, indicate that, to provide a channel 5 feet deep and 100 feet wide from the Bass River to Grand Rapids, a distance of about 23 miles, in the interest of recreational navigation would require the excavation of about 1,800,000 cubic yards of material. The total first cost of such a project would amount to about

TABLE IV-5
LOCAL SAND AND GRAVEL CONCERN

ANTICIPATED SAVINGS IN COSTS AS A RESULT OF
DEEPENING THE GRAND HAVEN HARBOR TO 25 FEET

Port	Allowable Draft	Anticipated Tonnage 1968	Anticipated Freight Cost 1968	% Saving	Anticipated Total Saving	Anticipated Tonnage 1973	Anticipated Freight @ 1968 Rate	% Saving	Anticipated Total Saving	Anticipated Tonnage 1978	Anticipated Freight @ 1968 Rate	% Saving	Anticipated Total Saving
Shipments:													
Buffalo	21-23	60,000	$ 136,000	5	$ 6,840	200,000	$ 456,000	5	$ 22,800	210,000	$ 478,000	5	$ 23,940
Cleveland	23	325,000	438,750	10	43,875	350,000	472,500	10	47,250	360,000	486,000	10	48,600
	27	0				250,000	337,500	20	67,500	260,000	351,000	20	70,200
Detroit	27	0				30,000	33,300	20	6,660	40,000	44,400	20	8,880
Hamilton, Ontario	25	75,000	150,000	20	30,000	90,000	180,000	20	36,000	100,000	200,000	20	40,000
Lorain, Ohio	23	10,000	11,500	10	1,150	0		10	0	0		10	
Port Weller	25	90,000	167,400	20	33,480	110,000	204,600	20	40,800	120,000	223,200	20	44,640
Sarnia, Ontario	22	60,000	66,600	5	3,330	100,000	111,000	5	5,550	100,000	111,000	5	5,550
Sombra, Ontario	22	20,000	22,200	5	1,110	0		5	0				
Windsor, Ontario	24	135,000	149,850	15	22,478	150,000	166,500	15	24,975	160,000	177,600	15	26,640
Receipts:													
Port Inland	25	60,000	60,000	20	12,000	75,000	75,000	20	15,000	95,000	95,000	20	19,000
					$154,263				$266,535				$ 287,450
Time Savings in Loading @ 1 Hour per Boat					37,000				34,800				36,900
Time Savings for Foundry Sand with New Loading Facility					52,200				106,500				114,000
Other Savings:													
According to a) Columbia Steamship Co.					20,000				25,000				30,000
b) Gartland Steamship Co.					4,200				5,250				4,620
TOTAL SAVINGS					$267,663				$438,085				$ 472,970

$2,500,000, not including the cost of land for spoil disposal. The average annual maintenance cost is estimated at about $60,000, based on previous experience gained in connection with the existing Federal project on the Grand River between Grand Haven and Bass River. The total annual charges, including cost of maintenance, would amount to approximately $160,000.

In order to economically justify such an expenditure of funds, the number of boats using the improved channel would have to amount to at least 400 locally based craft and 4,000 transient boats annually. It is considered reasonable to expect that traffic of at least this magnitude would develop should the channel to Grand Rapids be improved. Channel width and depth were determined by the navigational requirements of a cruiser up to 65 feet in length. As these requirements are greater than those of smaller craft, they automatically provide for the adequate navigational needs of smaller craft. It is expected that many of the vessels on the Grand River will be inboards and cruisers in the 17 to 40 foot long class. However, the river is sufficiently wide, with many tributaries and coves, so that joint use of the river by power boat enthusiasts, sailors, canoeists, and fishermen, may be pursued with recreational enjoyment by all without interference. This joint use provides maximum recreational advantages and is an important part of project justification. Some of the factors which indicate that this channel improvement may be economically feasible are the present popularity of recreational boating and the expected continuation of this trend, the heavily populated Grand Rapids area which provides a market for prospective boat purchasers and a destination for transient boaters, the relative lack of boating facilities in the Grand Rapids area, and access to Lake Michigan and its heavily traveled coastline. The minimum vertical clearance under high water conditions for any of the fixed bridges in this section of the river is 15 feet which will allow passage of almost any cruiser-type vessel.

(4) Recreational - Upstream of Grand Rapids. An investigation was made as to the economic feasibility of providing an improved channel for recreational boating upstream of Grand Rapids. The plan investigated

was that suggested by the Waterways Division of the Michigan Department of Natural Resources comprising a lock at Grand Rapids, a channel 80 feet wide and 5 feet deep to Lowell, and a channel 50 feet wide and 4 feet deep to the dam at Lyons. This covers a river distance of about 55 miles and passes under 17 bridges, mostly at Grand Rapids and the principal towns along the route. In order to provide a through channel a lock must be constructed at the Grand Rapids dam where the difference in water elevation is 18 feet. Upstream of Grand Rapids the river width varies from 100 to 1,950 feet with an average width of about 200 feet. Depths in this reach of the river vary considerably, but probably average about 2 feet under low water conditions. The river bed is composed almost entirely of sand and gravel and frequent bars obstruct the channel.

Preliminary estimates made to determine the cost of the suggested plan of improvement indicate that it would cost about 5 million dollars to provide for recreational navigation on the Grand River upstream of Grand Rapids. This includes the cost of a lock, but not the cost of any bridge modifications that might be necessary. The total annual charges for such an improvement, including annual maintenance, would be about $400,000. To obtain annual benefits equal to the estimated annual charges would mean that at least 800 locally based boats ranging in length from 17 to 65 feet would have to be based in this reach of the river and well over 10,000 transient craft visits would be required annually. There is no indication that such a volume of traffic would materialize in the near future should the considered improvement be constructed. Therefore, based on the limited information available, it is concluded that improvement of the Grand River upstream of Grand Rapids is not economically justified at this time. Should the future demand far exceed that which can be reasonably foreseen at the present time, the subject of an improved navigation channel upstream of Grand Rapids should be restudied.

The Lyons dam is the first of a series of four dams over a 14-mile reach of river extending from Lyons to Portland. Water depths of up to 30 feet exist in some of the pools upstream of the dams. Providing a channel 50 feet wide and 4 feet deep between the dam sites, to accommodate trailer-drawn craft and small boats which can be portaged around the dams, involves the removal of shoals and bars and is primarily

a clearing and snagging type project. This work also cannot be economically justified in itself since the number of craft needed to make such an improvement feasible cannot be reasonably anticipated in the near future. This improvement could also be restudied along with the reach between Grand Rapids and the Lyons dam should future conditions change sufficiently to justify such action. Impoundments of the Grand River or its tributaries between Portland and Lansing and between Lansing and Jackson to provide lakes for recreational boating could best be realized by the construction of reservoirs justified on a multiple-purpose basis rather than through single-purpose navigation projects.

c. Additional Studies Authorized. There are currently two authorized studies concerning the modification of existing projects or adoption of new projects at Grand Haven Harbor and on the Grand River. One study, in accordance with House Public Works Committee Resolution dated 1 March 1950, is to investigate the need for further improvements in the interest of commercial navigation. Although the original intent of local interests was to consider the advisability of improving a branch of the Grand River known as the "South Channel," local interests subsequently modified their request to include other improvements in lieu of the South Channel. At a public hearing held in Grand Haven on 26 March 1968, local interests proposed the following improvements: (1) deepen the existing deep-draft harbor channel to a minimum depth of 25 feet; (2) deepen and widen the turning basin; and (3) deepen, widen, and straighten the existing shallow-draft river channel from Grand Haven to the Bass River. Improvement of the harbor channel and turning basin will permit utilization of larger, modern lake vessels with a resultant savings in transportation costs. The requested river channel improvement will allow the use of larger barges and larger tows thereby decreasing the number of trips required. Work on this study has been initiated. The other authorized study is to determine if any modification of the existing project is advisable and is in accordance with House Public Works Committee resolution adopted 9 April 1957. This study will cover all aspects of recreational boating activity, with particular emphasis on improvement of the Grand River from the Bass River to Grand Rapids for small-craft navigation. Work on this study has not yet been initiated.

5. ELECTRIC POWER

a. Market for Power. The Grand River Power Region approximates the hydrologic boundary of the Basin except that it follows county lines. The Power Region consists of the following eleven Michigan counties: Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa, and Shiawassee. Locations of high load concentration within the Power Region are influenced by major economic centers designated as Standard Metropolitan Statistical Areas (SMSA's). There are three SMSA's within the Power Region: Grand Rapids, composed of Kent and Ottawa Counties; Lansing, composed of Clinton, Eaton and Ingham Counties; and Jackson, composed of Jackson County. They have been chosen as three of the five power subareas. The remaining two subareas are the Northeast Fringe, consisting of Gratiot and Shiawassee Counties, and the West Central Belt, consisting of Montcalm, Ionia, and Barry Counties.

The Grand River Basin Power Region is currently an importer of electric energy, and it is expected that the Region will continue to import in the future at about the present rate. In 1965 about 41 percent of the Region's energy requirement was imported from plants located outside the Region. By the year 2020 it is projected that this import will amount to about 44 percent. Table IV-6 shows the projected amounts of energy imported into the Region at intervals throughout the study period.

At the present time the bulk of the energy generated within the Power Region is located in the Grand Rapids and Lansing Subareas. It should be noted that the Campbell plant of Consumers Power Company, the largest plant in the Power Region, is located in the Grand Rapids Subarea on the shore of Lake Michigan. Although this is outside the Grand River Basin drainage area, it is within the area defined as the Power Region and therefore has not been considered as an import in this report. In addition, Consumers Power Company has stated that, because of inadequate cooling water in the Grand River basin for the size units being contemplated, all proposed installations to serve the Basin would be located on the Great Lakes. A major portion of the supply for the Grand Rapids Subarea (about 95 percent) will be located outside the Basin drainage area but in the Subarea as defined in this study. Consequently, the Grand Rapids and

Table IV-6

Grand River Basin Power Region
Existing and Projected Energy Requirements and Supply
(1000 kwh)

Subarea	Total Energy Required	Hydro Production 1/	Net Region Import	Thermal-Electric Production
		1960		
Grand Rapids	1,908,000	24,560	1,684,547	198,893
West Central Belt	255,000	21,960	201,264	31,776
Northeast Fringe	207,000	1,035	199,492	6,473
Lansing	1,235,000	3,356	396,411	835,233
Jackson	545,000	-	545,000	-
Total Region	4,150,000	50,911	3,026,714	1,072,375
		1965		
Grand Rapids	2,688,000	18,613	466,748	2,202,639
West Central Belt	364,000	16,245	301,066	46,689
Northeast Fringe	292,000	699	283,401	7,900
Lansing	1,807,000	1,005	589,898	1,216,097
Jackson	779,000	-	779,000	-
Total Region	5,930,000	36,562	2,420,113	3,473,325
		1980		
Grand Rapids	7,515,000	47,400	3,496,000	3,971,600
West Central Belt	1,005,000	63,700	941,300	-
Northeast Fringe	815,000	700	814,300	-
Lansing	4,865,000	3,700	2,529,000	2,332,300
Jackson	2,150,000	-	2,150,000	-
Total Region	16,350,000	115,500	9,930,600	6,303,900
		2000		
Grand Rapids	18,760,000	47,400	5,060,000	13,652,600
West Central Belt	2,510,000	63,700	2,446,300	-
Northeast Fringe	2,030,000	700	2,029,300	-
Lansing	12,140,000	3,700	6,068,000	6,068,300
Jackson	5,360,000	-	5,360,000	-
Total Region	40,800,000	115,500	20,963,600	19,720,900
		2020		
Grand Rapids	35,630,000	47,400	5,680,000	29,902,600
West Central Belt	4,760,000	63,700	4,696,300	-
Northeast Fringe	3,860,000	700	3,859,300	-
Lansing	23,060,000	3,700	9,796,000	13,260,300
Jackson	10,190,000	-	10,190,000	-
Total Region	77,500,000	115,500	34,221,600	43,162,900

1/ Based on average annual energy for years 1980, 2000, and 2020.

Lansing Subareas will continue to supply a substantial portion of their own requirements. The three remaining Subareas, West Central Belt, Northeast Fringe, and Jackson, which have historically been supplied by imports, will continue to be supplied by imports in the future.

Forecasts indicate that the future increased power requirements of the Grand River basin will be supplied from outside the Basin with the exception of the requirements of the City of Lansing. The Lansing Board of Water and Light plans to build a third steam-electric power plant on the Grand River on a site in Section 34 of Delta Township, Eaton County. The first unit of 160 megawatts is scheduled for commercial operation in 1972. An ultimate capacity of 1500 megawatts to be built in stages over a 20-year period is planned. Cooling towers will be used requiring a diversion from the river of make-up water only. A small storage pond is also being considered for supplemental water supply during periods of extremely low stream flow.

b. Potential Hydroelectric Power. The natural conditions existing in the Grand River Basin Power Region do not favor extensive hydroelectric power developments. The highly developed agricultural lands, the numerous cities and towns, and costly transportation facilities within potential reservoir areas limit the possibilities for development of storage sites.

Undeveloped hydroelectric potential in the Region is estimated to be about 18,700 kw which could produce an average of about 78.4 million kwh of energy annually. This includes four potential sites and a capacity increase at the existing Portland site. A summary of data for these sites is included in Table IV-7, and their locations are shown in Figure IV-1.

Projects considered as potential in this report are not necessarily economically feasible to develop at this time. In order to screen these projects, they need to be investigated as to their estimated development cost, the value of the potential capacity and energy available, size of plant, and transmission required, when specific projects are formulated. The value of the potential hydroelectric supply is considered to be equivalent to the cost of developing and operating the most likely alternative source of supply. This would, in most instances, be a thermal electric plant of the type currently being installed.

Table IV-7

Grand River Basin Power Region
Possible Future Hydroelectric Developments

Project Name	River	Drainage Area (sq.mi.)	Gross Head (ft)	Installed Capacity (kw)	Avg. Annual Energy (1000 kwh)	Avg. Flow Utilized (cfs)	Hydraulic Capacity (cfs)
Grand Rapids	Grand	4,900	17	6,700	30,000	2,880	5,630
Saranac	Grand	2,980	16	3,700	16,700	1,700	3,300
Portland 1/	Grand	1,695	20	2,400	5,400	440	1,710
McGee	Grand	1,395	32	3,300	14,200	720	1,470
Danby	Grand	1,325	32	2,600	12,100	620	1,160

1/ Redevelopment of existing site

GRAND RIVER BASIN
EXISTING GENERATING PLANTS
& POSSIBLE FUTURE HYDROELECTRIC PLANTS

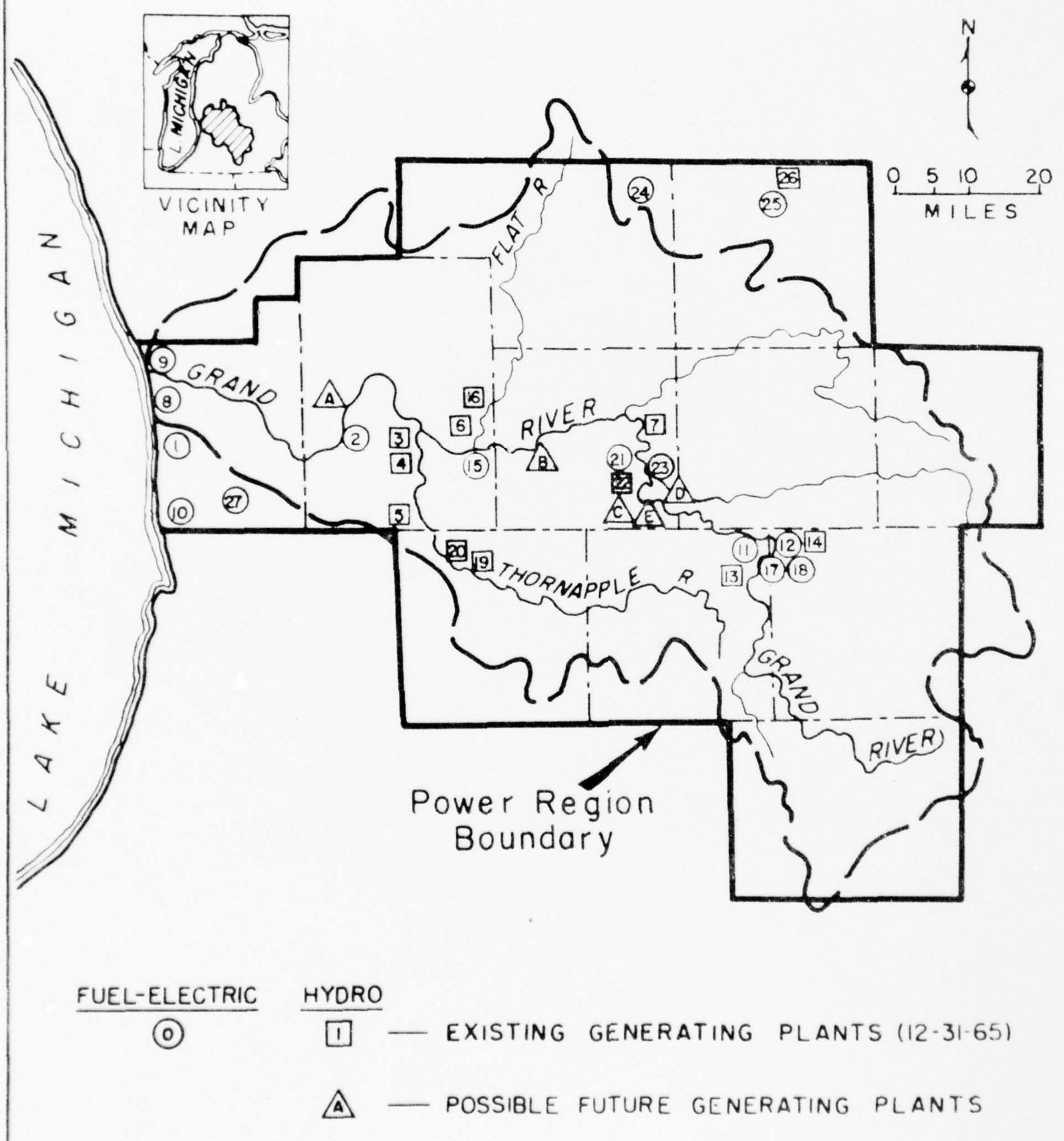

Figure IV-1

The amount of possible future hydroelectric supply involved is small in relation to the total basin supply and would have a negligible effect on the future thermal supply required. However, for purposes of this study, all of the known potential hydroelectric power projects have been included in the future capacity supply.

6. FLOOD DAMAGE REDUCTION

a. General. The flood control study is in two parts: first, main stem and principal tributaries; second, upstream watershed areas. The upstream watershed flood control studies are described in detail in Appendix M, Agriculture, of this report. The Department of Agriculture's Soil Conservation Service and the Corps of Engineers agreed to define these areas to avoid duplication of work. The study is broken down by reach as follows:

REACH DESCRIPTION

Corps of Engineers

a. Grand River, main stem up to Jackson (Mile 0 to 219)
b. Red Cedar River, main stem up to Williamston (Mile 0 to 22)
c. Lookingglass River, main stem up to DeWitt (Mile 0 to 25)
d. Stony Creek, up to Wright Road (Mile 0 to 12)
e. Maple River, up to US-27 Federal Highway (Mile 0 to 23)
f. Flat River, main stem (all)
g. Thornapple River, main stem (all)
h. Rogue River, main stem (all)

Soil Conservation Service

a. Portage River - main stem (all)
b. All upstream areas not specified for study by the Corps of Engineers

Many of the Grand River basin's major urban areas are subject to periodic flooding. The urban areas subject to flooding within the Basin, listed in Table IV-8, are located primarily along the main stem of the Grand River and along some of the major tributaries. The scope of study performed for each of these urban areas was based on the extent of damage potential that existed. The damage potential of each area was evaluated

TABLE IV-8

URBAN DAMAGE CENTERS

City	River Reach Miles from Mouth
Grand River	
1. Grandville	34.0 to 37.0
2. Grand Rapids	37.2 to 45.5
3. Plainfield Township	45.5 to 51.3
4. Ada	61.3 to 62.3
5. Lowell	69.6 to 71.0
6. Saranac	77.5 to 78.2
7. Ionia	86.9 to 89.2
8. Lyons	95.3 to 96.2
9. Portland	112.2 to 113.5
10. Grand Ledge	139.0 to 142.0
11. Lansing	150.5 to 158.0
12. Dimondale	164.4 to 165.1
13. Eaton Rapids	180.0 to 181.5
14. Jackson	217.0 to 219.5
Red Cedar River	
15. East Lansing	3.3 to 7.2
16. Okemos	9.5 to 10.9
17. Williamston	20.2 to 22.2
18. Fowlerville	about 33
Sycamore Creek	
19. Mason	12.7 to 14.6
Maple River	
20. Muir	0.6 to 0.9
21. Maple Rapids	about 19
22. Ovid	about 54
Thornapple River	
23. Hastings	about 42

through field reconnaissance, contacts with local people, and available office data. Detailed studies indicated that damages would be significant. The scope established for these detailed studies is preliminary; however, enough detail is contained to estimate the economic feasibility of different plans of improvement. These studies consisted of description and identification of the flood problem, and estimates of several plans of improvement (such as local protection, area evacuation, and flood control reservoirs) to alleviate the flood problem. In addition, flood control plans were compared to each other. Pertinent flood data for areas for which detailed studies were made are presented in table IV-9.

The flood control studies for the urban centers revealed that control structures can be devised to successfully shield the centers from the expected floods; however, the monetary costs of the structures are prohibitive for the benefits that would accrue. These control structures are set forth in appendix H; they are not recommended for adoption. Similarly, the floods can be controlled by reservoirs; however, single-purpose flood control reservoirs are not economically feasible in the Basin.

When storage in reservoirs at certain locations is proportioned among multiple purposes (flood control, water quality, water supply, recreation, and fish and wildlife), a favorable balance between benefits and costs emerges. In the investigation of this aspect, the Corps of Engineers inventoried 79 possible sites and the Soil Conservation Service inventoried an additional 132. From these 211 possible sites, 6 reservoir sites with flood prevention capabilities proved to be economically and socially acceptable. They are Site No. 7 (Onondaga) of the Jackson Complex, Sites Nos. 57C (Okemos) and 58 (Williamston) of the Red Cedar Complex, Site No. 22 (Labarge), Site No. 42 (Prairie Creek), and Site No. 51 (Portland). This is to say that these pools and reservoirs combine flood control with other purposes successfully.

b. Flood Control Benefits. At the outset, it probably should be explained that market-valued benefits generated by flood control installations may or may not accrue every year as other benefits are valued.

TABLE IV- 9

MAJOR FLOOD DAMAGE CENTERS

Community	Upstream Drainage Area	Record Flood Data			
		Year	Stage (USGS)	Maximum Discharge	Average CFS/SM
Grandville	5,000	1904	605.4	54,000	10.8
Grand Rapids	4,900	1904	609.9	54,000	11.0
Plainfield Twp.	4,850	1904	617.1	54,000	11.2
Ada	4,000	1904	628.2	52,500	13.1
Lowell	3,640	1904	633.7	44,000	12.1
Ionia	2,840	1904	643.5	45,000	15.8
Lyons	1,777	1904	653.8	32,600	18.4
Lansing	1,230	1904	825.8	24,500	19.9
Eaton Rapids	661	1947	868.8	8,900	13.4
East Lansing*	355	1947	835.9	5,920	16.6

* East Lansing is on the Red Cedar River; all other communities listed are on the Grand River.

They are estimated on the basis of damages that are caused by floods at certain periods, some interval apart in time. These intervals may be as little as one year or as much as 50 years. The expense of damage repair is then averaged over these years and reported as average annual benefits.

Total flood control benefits that materialize from the operation for flood control of the reservoir at Site No. 7 (Onondaga) of the Jackson Complex, are estimated to be $50,000 annually. Total flood control benefits for reservoirs Nos. 57C (Okemos) and 58 (Williamston), of the Red Cedar Complex, are estimated to be $250,000 annually. For the reservoirs of Sites Nos. 22 (Labarge), 42 (Prairie Creek), and 51 (Portland), total annual flood control benefits are calculated to be $200,000; $40,000; and $56,000 respectively. To present a somewhat more detailed conception of the economies of the flood control reservoir operation, further analyses have been tabulated which show the benefits at certain locations due to certain projects. These, together with other relevant information, are in Tables IV-10 and IV-11.

c. Flood Control Solutions Considered and Rejected. There are diverse methods of dealing with river floods to restrict or eliminate the damages they may create, depending on the geographical location. Many years ago, of its own volition, the city of Jackson encased the Grand River in a concrete conduit through the central business district and improved the north river channel. At the downstream end of the Grand, the city of Grand Rapids, after the 1904 flood, constructed flood-retaining walls and levees along the river banks within the city limits. Both schemes were successful, so there are precedents for the technical success of these methods. In the Basin, at each of the major urban damage centers, a full range of flood control protection methods, which lend themselves to this Basin, were examined and tested. These methods are upstream retarding reservoirs, levees and flood walls, channel improvements, and flood plain evacuation. Excepting reservoirs at Sites Nos. 7 (Onondaga), 57C (Okemos), 58 (Williamston), 22 (Labarge), 42 (Prairie Creek) and 51 (Portland), prudent schemes utilizing these methods or a combination of

TABLE IV-10

SUMMARY OF ANALYSIS OF

RESERVOIRS UPSTREAM FROM LANSING THAT EXERT FLOOD CONTROL

RESERVOIR SITES			REDUCTION BENEFITS* (Dollars)					PRELIMINARY COST (Dollars)				
NO.	NAME	SIZE AC. FT. Flood Pool	EAST LANSING Residual Damage	EAST LANSING Potential Benefits	LANSING Residual Damage	LANSING Potential Benefits	TOTAL (5)+(7)	FIRST COST	AVERAGE ANNUAL COST	ANNUAL O&M COST	ANNUAL TOTAL (10)+(11)	BENEFIT COST RATIO
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
59	OKEMOS	10,000	21,468	213,272	13,316	41,277	254,549	4,394,000	175,000	29,000	204,000	1.25
58	WILLIAMSTON	20,000	22,614	212,126	17,249	37,344	249,470	10,221,000	407,000	46,000	453,000	0.55
57	ONONDAGA	30,000			12,448	42,144	42,144	6,750,000	269,000	37,000	306,000	0.14

TABLE - 11

SUMMARY OF ANALYSIS OF
RESERVOIRS DOWNSTREAM FROM LANSING THAT EXERT FLOOD CONTROL

NO.	NAME	SIZE AC. FT. Flood Pool	IONIA Residual Damage	IONIA Potential Benefits	LOWELL Residual Damage	LOWELL Potential Benefits	GRAND RAPIDS Residual Damage	GRAND RAPIDS Potential Benefits	TOTAL (5)+(7) + (9)	FIRST COST	AVERAGE ANNUAL COST	ANNUAL O&M COST	ANNUAL TOTAL (12)+(13)	BENEFIT COST RATIO
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
22	LABARGE	80,000					179,392	208,834	208,834	6,750,000	267,000	37,000	304,000	0.69
42	PRAIRIE CREEK	10,000	45,003	2,629	48,792	7,007	353,399	34,827	44,463	1,500,000	60,000	10,000	70,000	0.63
51	PORT-LAND	20,000	41,721	5,911	46,904	8,895	346,820	41,407	56,213	2,320,000	92,000	17,000	109,000	0.51

them are too costly in proportion to the benefits derived. Detailed expositions including plates showing the layouts of these examinations are in appendix H. In addition to the above, the communities of Hastings, Muir, Maple Rapids, Ovid, Okemos, Williamston, and Fowlerville have occasional flood damages. These were not studied in detail on the premise that such studies were not warranted.

d. Effects of Valley Preserves on Level of Flood Damages. The valley preserves recommended are to a great extent for flood damage reduction. What will be their value? Certainly with the management of the flood plains of the Grand and major tributaries for this purpose, flood damage to private improvements that would likely otherwise locate on them would disappear. Easily accessible tracts of primeval setting would also afford many benefits of well being, relaxation, recreation, and physical reconstitution. Important migrations of industry and population to locations adjacent to valley preserves may occur. Vigilance will be necessary to insure that adjacent commercialism does not mar the setting of the several reaches.

7. RECREATION

a. Alternatives. Several alternatives were available for consideration in the development of a recreation plan for this Basin. They included: (1) continued expansion of existing State and local parks, (2) development of new parks on existing lakes, (3) development of new parks on new impoundments, (4) development of new parks on Lake Michigan, (5) development of recreation areas along major streams, (6) development of facilities by the private sector, and (7) transfer of needs to areas outside the Basin.

Some of the existing State parks have little or no room for expansion on existing land holdings. Acquisition of additional land would be very expensive, especially where it would consist of lake frontage and nearby property. On most lakes, the desirable frontages have been platted and developed for cottages and permanent residences. Some state parks do have expansion room, but their water surface is being utilized to its full extent; thus, development of additional facilities could be accomplished only for land-based activities. Several new State parks have substantial undeveloped space.

Land for new State parks could be acquired and developed on several of the larger existing lakes, but it would require the purchase of many small tracts of residential or cottage property at a very great cost. These lakes are already being used heavily for boating, fishing, and, to some extent, for swimming by abutting and nearby property holders. Thus, new parks developed on existing lakes could provide additional opportunities for land-based activities and swimming, but there appears to be only limited opportunity for the development of additional opportunities for other water-based activities. In any case, acquisition of a sufficient area of land would be very high.

There is substantial opportunity for the development of facilities for all types of recreational activities on new impoundments. Such impoundments and the adjacent land area could be developed without limitations imposed by intensive residential development present on most existing lakes.

The shore of Lake Michigan presents problems somewhat similar to those found on existing small inland lakes; that is, the shore in many places has been developed intensively for residential use. Thus, the State finds it difficult to acquire large tracts of land on the lakeshores. In addition, while the lake presents excellent opportunities for swimming, it offers very limited opportunities for boating, water skiing, and fishing from small craft.

The flood plains of the major streams in the Basin present an excellent opportunity to extend recreation areas close to urban centers. They also present the potential for the development of a wide variety of activities, although opportunities for boating would be limited to small boats. Implementation of the valley preserve concept appears to be the most difficult problem to solve.

The private sector should be encouraged to develop recreational facilities, especially for land-based activities, in areas of substantial need. The private sector cannot be expected to develop water surface for recreational use, except as small impoundments are developed in conjunction with residential development or for pay fishing. However, the private sector could provide opportunities for camping, picnicking, and swimming and, to a lesser extent, other related land-based activities.

Another set of alternatives needs to be considered at this point. The task of attempting to develop water surface to satisfy needs for powerboating and water skiing within the Basin by the year 2020 is economically and almost physically impossible.

Therefore, those individuals who desire to participate in these activities will probably have to: (1) accept much lower standards for space than those used in the development of projected needs in the report, (2) spread their participation in such activities throughout the week, (3) seek opportunities to satisfy their desire for water-dependent activities on facilities located outside of this watershed, and/or (4) seek the satisfaction of their desires in other recreational activities.

The acceptance of lower space standards would increase the potential for bodily injury and conflict with other water-based activities. Existing and planned areas of water surface have the potential to satisfy much greater quantities of need for water-based activities if such areas are more fully utilized throughout the week rather than just on weekends.

Recreationists will need to satisfy their desires for outdoor activities in some type of activity other than powerboating and water skiing. At this time, however, it would be only conjecture to attempt to determine what activities might be used as substitutes.

Some of the needs arising from weekend use could be transferred to areas north of the Basin. On the average, about 37 percent of total demand in the Basin is derived from weekend use. Many lakes within 125 miles of the Basin boundary are already heavily used. However, there are numerous opportunities to develop sites for camping, picnicking, and related activities along streams in the State and National forests.

b. Plan of Development. The objective of recreation planning is to provide the public with sufficient usable water and related land-based recreational facilities to reasonably satisfy the public demand. To be totally complete, a recreation plan should include the proposed development of recreational facilities by all levels of government and the private sector. However, in a plan of the magnitude being developed for the Grand

River basin, it would be very difficult to identify specific developments proposed by individual local units of government. In addition, the private sector will function only in those areas where there is opportunity to make a profit without undue risk. Therefore, the recreation plan set forth in the following pages is limited to those segments that would be developed by the Federal and State governments and to the certain major segments of development involving local units of government.

Insofar as reasonably possible, reservoirs included in the early action plan were selected for their capacity to satisfy needs in a quality environment. However, in several instances, it will be necessary to transfer needs from one subarea to another or to areas outside the Basin because developable sites within the Lansing and Northeast Subareas are very limited. Thus, small surpluses of facilities for several activities in the Jackson and Grand Rapids Subareas can accommodate unmet needs in the other Subareas.

The level of development proposed for each of the reservoir sites listed in this section represents an initial level only. Since it is proposed to acquire all land that would be needed for full development when the reservoir is constructed, additional facilities could readily be constructed to meet new needs as they develop in the post 1985 period.

The level of ultimate development proposed for each of the sites listed in the Basin Plan ranges from about 10 to 15 percent of the total land area for the eight activities used in this study. The inclusion of additional space to accommodate other activities not considered in this study would require an additional three to five percent of the land area. Thus, total development of space for intensive use would amount to about 15 to 20 percent of the total recreation area.

Since the Plan Formulation Subcommittee set the target date for the early action program back from 1980 to 1985, because of the closeness of the year 1980, the same procedure will be followed in this plan. Needs for acres of developed land by activity were adjusted from 1980 to 1985 by increasing them by a proportionate share of the increase in needs between 1980 and 2000. Needs for 1985 are set forth in table IV-12.

Table IV-12

Adjustment of 1980 Recreation Needs to 1985

	Needs in Acres of Developed Land		25% of Diff.	Needs in Acres of Developed Land
Basin Summary	1980	2000		1985
Swimming (land)	118	288	42	161
Boating (land)	284	567	71	355
and				
Water Skiing (Water)	38,500	108,300	17,500	56,000
Camping	450	1,381	233	682
Picnicking	487	1,247	190	677
Parking	336	756	105	441
Jackson Subarea				
Swimming (land)	10	28	5	15
Boating (land)	25	56	8	33
and				
Water Skiing (Water)	600	8,600	2,000	2,600
Camping	(18)*	82	25	7
Picnicking	4	84	20	24
Parking	25	70	11	36
Lansing Subarea				
Swimming (land)	45	85	10	55
Boating (land)	77	146	20	97
Water Skiing (Water)	17,100	33,900	4,200	21,300
Camping	153	381	57	210
Picnicking	152	337	46	198
Parking	107	209	26	133
West Central				
Swimming (land)	21	67	11	32
Boating (land)	62	137	19	81
and				
Water Skiing (Water)	2,900	20,900	4,500	7,400
Camping	123	369	61	184
Picnicking	172	375	51	223
Parking	55	167	28	83

Table IV-12 (Cont'd)

	Needs in Acres of Developed Land		25% of Diff.	Needs in Acres of Developed Land
Grand Rapids	1980	2000		1985
Swimming (land)	5	39	9	14
Boating (land)	61	118	14	75
and				
Water Skiing (Water)	4,500	18,900	3,600	8,100
Camping	51	239	47	98
Picnicking	(44)	108	39	(5)
Parking	50	133	21	71
Northeast				
Swimming (land)	37	69	8	45
Boating (land)	59	110	13	72
and				
Water Skiing (Water)	13,400	26,000	3,200	16,600
Camping	140	310	43	183
Picnicking	203	343	34	237
Parking	99	177	19	118

(1) Priorities. A priority system for the utilization of existing resources and the development of new resources is established to obtain the most recreation facilities for the available dollar. Insofar as feasible, it is established as follows: (1) full utilization of existing resources, such as lakes, rivers, and State and local parks where they have underdeveloped lands; and (2) development of new facilities, such as reservoirs and valley preserves.

In addition to the establishment of the above priorities, a priority system is established for subareas with the greatest need as follows: (1) the Lansing and Northeast Subareas since they have great needs and very limited recreational opportunities; (2) the Jackson Subarea, since the Sandstone Creek Reservoir can satisfy a substantial part of the needs which cannot be satisfied in the Lansing Subarea and since this Subarea receives heavy impact from the Detroit Metropolitan Area; (3) the Grand Rapids Subarea which receives very heavy impact from out-of-Basin visitors along the Lake Michigan shore and from the Grand Rapids SMSA; and (4) the West Central Subarea.

(2) Subarea Plans.

(a) Jackson Subarea. The Jackson Subarea, well endowed with high quality resources, is strategically located with respect to large population centers in southern Michigan. It receives heavy impact from the Detroit, Ann Arbor, and Lansing Metropolitan areas. The Detroit and Lansing SMSA's are especially short of quality resource areas for development of recreational opportunities.

1. Needs. The Jackson Subarea shows a need in 1985 for 15 acres of swimming beach, seven acres of camping, 24 acres of picnicking, 33 acres of boat launching and parking area, 36 acres for other parking, and 2600 acres of water surface. Need shown for camping is small. However, it must be kept in mind that, as stated previously in this report, the needs are understated in this subarea because of the empirical methodology used.

According to the Michigan Outdoor Recreation Plan, the State plans to increase the number of camp sites from 802 to 2750 in District 13, which includes Jackson County, between 1964 and 1975. One-half of

the 802 sites are located in the Waterloo Recreation Area in Jackson County. They plan to increase parking spaces by five-fold. Other needs are probably understated to a similar extent.

2. Priorities. The Sandstone Creek Reservoir, Site No. 62, should be given high priority in this subarea, since it has excellent potential for the development of recreational facilities and since it is strategically located with respect to the Jackson, Lansing, and Detroit SMSA's.

Second priority should be given to the development of additional camping, picnicking, and parking facilities in the Waterloo Recreation Area. Also, additional public access should be developed concurrently on natural lakes presently without public access in this subarea but having potential for additional use.

3. Plan of Development.

a. New Reservoirs. The Sandstone Creek Reservoir would be located about eight miles northwest of the City of Jackson and could serve the Jackson and Lansing Subareas which have severe shortages of natural water surface and recreational facilities. With easy access from Interstate Highway 94, this site would be readily available to people in the Detroit and Ann Arbor Metropolitan Areas.

The dam for the Sandstone Reservoir would be located on Sandstone Creek in Section 21, T1S, R2W, just upstream from the Village of Tompkins Center. At an elevation of 950 feet mean sea level (m.s.l.) the surface area would be about 7800 acres. It is proposed to store a substantial quantity of water for water quality control in this reservoir. Therefore, a second dam would be constructed across the midsection of the impoundment to provide a stable pool with about 3,000 acres of surface water in the upper part of this impoundment solely for recreation and fish and wildlife uses. The lower part of this reservoir would still provide great opportunity for the development of those activities not seriously affected by drawdown in late summer and fall.

The proposed recreation lands around the reservoir are undulating to strongly rolling and are very well suited for recreational development.

There are many small tracts of woodland and wide fence rows on these upland areas. In addition to the lands required for the impoundment, about 5000 acres should be acquired for development of recreational facilities.

This proposed reservoir site will support a broad range of recreational activities. The State of Michigan considers this to be one of the best potential sites for recreational development in the southern half of the lower peninsula. The site is well located with respect to large urban centers and highway arteries. No other site in the southeastern part of the State can approach it for recreational potential.

b. Existing Recreation Areas and Lakes. Additional camping, picnicking, and related facilities should be developed in the Waterloo Recreation Area. However, this area provides little, if any, opportunity for the development of facilities for most water-dependent activities. According to the State of Michigan, most of the lakes are being utilized to their full capacity, but public access should be acquired on those with unused recreation potential.

4. Amount of Development. It is proposed that the following facilities be developed in these locations. Development on the Sandstone Reservoir represents the initial level only; additional development could be added in later years to meet new needs as they arise.

Resource Area	Acres of Developed Land					Acres of Water Surface
	Swimming	Boat Access	Camping	Picnicking	Parking	
Sandstone Reservoir	12	10	67	60	31	7,800
Waterloo Rec. Area	--	--	8	10	2	-----
Public Access on Lakes	--	5	--	--	--	-----
Total	12	15	75	70	33	7,800

5. Percent of Needs Satisfied. This level of development will satisfy 80 percent of the swimming needs, 45 percent of the boat launching and parking needs, and 90 percent of other parking needs. It will provide a surplus in camping and picnicking, but since the Sandstone Reservoir is located near the Jackson-Lansing Subarea boundary, and since opportunities to develop recreational facilities in the Lansing Subarea are very limited, these surpluses can be utilized to offset a part of the needs in that area.

(b) Lansing Subarea. The Lansing Subarea has only limited opportunities for the development of major recreation areas. Much of the land has low relief presenting only limited opportunities for the development of good reservoirs. In planning, consideration should be given to transferring some of the needs to other subareas.

1. Needs. The Lansing Subarea will have a need for the development of 55 acres of swimming beaches, 97 acres of boat launching and parking area, 210 acres of camping areas, 198 acres of picnic areas, 133 acres of other parking area, and 21,300 acres of water surface by 1985. Needs for other activities are also present, but they were not calculated individually.

2. Priorities. First priority should be given to the completion of Sleepy Hollow State Park. Initial facilities proposed for this park are already included in programmed supply. Also, public access should be developed on those lakes that can provide a significant amount of recreational opportunities.

Since natural features that can supply substantial amounts of recreational opportunities are so limited, second priority should be given to the development of three reservoir sites for recreational development; they are, in order of need, the Doan Creek Site, Site No. 59, located about 15 miles southeast of Lansing; the Portland Site, Site No. 51, lying astride the Lansing - West Central Subarea boundary near Portland; and the No Name Creek Site, Site No. 180, near Charlotte in Eaton County.

Third priority should be given to the initiation of the development of the valley preserve system along the Grand River.

3. Plan of Development

a. Existing Recreation Areas and Lakes. The Sleepy Hollow State Park should be developed to its ultimate potential as soon as possible. This will include the construction of additional camping, picnicking, and parking facilities.

b. New Reservoirs. The Doan Creek Reservoir would provide recreational opportunities for the Lansing, Flint, and Detroit Metropolitan Areas. The reservoir would be located on Doan Creek, a tributary of the Red Cedar River, about three miles southeast of the City of Williamston and about 15 miles southeast of Lansing. The structure would be located in Sections 17 and 18, T3N, R2E in Ingham County. The pool would contain a surface area of 2600 acres at an elevation of 900 feet and would be used exclusively for recreation, fish, and wildlife.

The lands immediately adjacent to the pool are undulating to sloping with dominant slopes of 3 to 15 percent. Lands lying beyond one-eighth to one-quarter of a mile from the pool generally have slopes of less than 3 percent and are used intensively for agriculture. About 2000 acres of land should be acquired for the development of recreation facilities. This reservoir would support a relatively wide range of recreation facilities.

The Portland Reservoir Site, lying only 18 miles northwest of Lansing and 40 miles east of Grand Rapids, would provide recreational opportunities to people in these metropolitan areas. The structure for this reservoir would be located in Section 34, T6N, R5W on the Lookingglass River about one mile east of the City of Portland in Ionia County. The conservation pool would contain about 1300 acres, at an elevation of 760 feet. This reservoir would also provide storage for flood flows.

The lands adjacent to the pool are undulating to strongly rolling with slopes of 3 to 15 percent being dominant. About 2500 acres should be acquired for the development of recreational facilities. This reservoir would support a wide range of recreational activities.

The No Name Reservoir would be located in Section 2, T3N, R5W, on a small tributary of the Thornapple River about seven miles north of

the City of Charlotte. It would service the Lansing and Battle Creek Metropolitan Areas and several local communities. The pool would contain about 300 acres at an elevation of 895 feet. It would be used exclusively for recreation, fish, and wildlife.

The land adjacent to the proposed reservoir is undulating to sloping with slopes of 3 to about 10 percent. In addition to land for the impoundment, about 1200 acres of land should be acquired for the development of landbased recreation facilities. This reservoir would support a general mix of recreational activities, but due to the limited water surface powerboating and water skiing should not be permitted.

The valley preserve should be initiated in the area along the Grand River upstream from Lansing. This system should be extended into the City of Lansing as rapidly as possible and below the City in anticipation of improvement in water quality in the river for limited recreational use.

4. Amount of Development. A summary of proposed initial development on the three reservoirs, Sleepy Hollow State Park and the valley preserve system would include development of the following land areas.

Resource Area	Acres of Developed Land: Swimming	Boat Access	Camping	Picnicking	Parking	Acres of Water Surface
Sleepy Hollow State Park	4	--	12	60	17	----
Portland Reservoir	6	5	40	33	17	1,300
Doan Creek Reservoir	5	4	20	27	13	2,600
No Name Reservoir	5	2	20	20	12	300
Valley Preserve System	--	2	--	5	4	-----
Total	20	13	92	145	63	4,200

5. Percent of Needs Satisfied. This level of development will satisfy about 36 percent of the swimming needs, about 13 percent of boat launching and parking needs, about 43 percent of camping needs, about 73 percent of picnicking needs, about 47 percent of other parking needs, and about 20 percent of water surface needs. However, a significant portion of the needs not satisfied in this subarea can be satisfied on the Sandstone Reservoir, only 30 miles from Lansing, and the Waterloo Recreation Area, in the Jackson Subarea. Also, local governments can satisfy a portion of the unmet needs.

(c) West Central Subarea. The West Central Subarea contains many resources with potential for development, including additional recreation reservoir sites and broad river valleys.

1. Needs. The needs in the West Central Subarea amount to 32 acres for swimming, 81 acres for boat launching and parking, 184 acres for camping, 223 acres for picnicking, 85 acres for other parking, and about 7,400 acres of water surface by 1985. In addition, there are needs for other activities but they were not calculated individually.

2. Priorities. First priority should be given to providing additional development in existing State and county parks where undeveloped lands are available and to providing public access on those lakes that have significant additional potential for use.

Second priority should be given to the construction and development of Prairie Creek Reservoir, Site No. 42. Also the Valley Preserve System should be developed from this site downstream to the junction of Prairie Creek with the Grand River and along the Grand River to the Ionia Recreation Area on the south bank.

Duck Creek Reservoir, Site No. 25, and Fish Creek Reservoir, Site No. 47A, should be considered in the third priority position for recreational facilities to meet 1985 needs with Duck Creek being constructed first.

3. Plan of Development

a. Existing Recreation Areas and Lakes. There are two State recreation areas, Yankee Springs on Gun Lake in Barry County and

Ionia Recreation Area near Ionia in this subarea. Also, the new Newaygo State Park is located just north of the Basin boundary in Newaygo County. All of them have potential for additional development of recreational facilities which should be installed as soon as possible.

Less than 10 percent of the total land area in the Yankee Springs Recreation Area has been developed for intensive use. This area can accommodate additional swimming, camping, picnicking, and related land-based activities.

The Ionia Recreation Area, containing about 3700 acres is in the early stages of development. While the water surface is only 85 acres, this area has nearly four miles of frontage along the Grand River. There is sufficient undeveloped land to accommodate additional picnicking, and other related land-based facilities. Many of the facilities proposed for this area have been included in programmed supply.

The new Newaygo State Park on the Hardee Dam Reservoir on the Muskegon River can accommodate boating, fishing, camping, picnicking, and other land-based activities. This area will total about 900 acres of land when it is completed.

While this subarea has many lakes currently without public access, most of them are relatively small and have been pre-empted with private development which limits the potential for development of public facilities. However, public access and sanitary facilities should be provided as a bare minimum on those lakes that have unused recreational potential.

b. New Reservoirs. The Prairie Creek Reservoir would be located about two miles north of the City of Ionia, about 35 miles northwest of Lansing, and the same distance east of Grand Rapids. It would service a large area with limited available recreational opportunities. The structure for this reservoir would be located in Section 9, T7N, R6W on Prairie Creek in Ionia County. At an elevation of 746 feet, the conservation pool would be about 1200 acres. This reservoir would also have some flood storage in it.

The lands surrounding this pool are sloping to strongly sloping with dominant slopes ranging from about 4 to 15 percent. The land is

well adapted for recreational development and contains a number of scattered wooded areas. In addition to the area required for the impoundment, at least 2500 acres of land should be acquired for the development of recreational facilities.

The structure site would be located in Section 29, T5N, R8W, in Ionia County. At an elevation of 820 feet, the pool would contain 940 acres of surface water. Other uses in this reservoir include fish and wildlife.

The adjacent lands are undulating to rolling with dominant slopes ranging from 3 to about 12 percent. Much of the adjacent land is now used for pasture and farm crops; scattered areas of woodlands are also present. In addition to the land needed for the impoundment, at least 2000 acres of land should be acquired for the development of recreational facilities.

Fish Creek Reservoir is located just north of the Village of Hubbardston about 30 miles northwest of Lansing and about 40 miles east of Grand Rapids. This reservoir could provide additional recreational opportunities to these and several smaller communities.

The structure site is located in Section 36, T9N, R5W, in Montcalm County. At an elevation of 750 feet, the pool would contain about 3200 acres of water. It would be used for recreation, fish and wildlife.

The adjacent lands are undulating to sloping with dominant slopes ranging from 3 to about 10 percent. Much of the adjacent land is now used for pasture, woodland, and some farm crops. About 3000 acres of land should be acquired for recreational development in addition to the pool area.

c. Valley Preserves. The flood plain along Prairie Creek between the Prairie Creek Reservoir and the Grand River should be acquired at the same time that the reservoir is constructed. This segment of the valley preserve should be extended downstream along the Grand River and be tied into the Ionia Recreation Area and eventually into a valley preserve system extending along the entire length of the Grand River. Development of recreational facilities in this area should be limited to trails, picnicking, and other compatible activities.

4. Amount of Development. The following development is suggested for each of the resource areas proposed for development in this subarea.

Resource Area	Acres of Developed Land: Swimming	Boat Access	Camping	Picnicking	Parking	Acres of Water Surface
Yankee Springs Rec. Area	3	--	25	20	9	-----
Ionia Rec. Area	--	--	--	40	8	-----
Newaygo State Park	--	3	50	15	3	-----
Prairie Creek Reservoir	5	9	40	27	13	1,200
Duck Creek Reservoir	5	7	33	26	11	940
Fish Creek Reservoir	5	18	40	30	13	3,200
Public Access on Lakes	--	10	--	--	--	-----
Total	18	47	188	158	57	5,340

5. Percent of Needs Satisfied. The proposed level would satisfy about 56 percent of the swimming needs, about 58 percent of the boat launching and parking needs, about 102 percent of camping needs, about 70 percent of picnicking needs, about 68 percent of parking needs, and about 72 percent of water surface needs. A significant portion of those needs not satisfied on the proposed developments could be satisfied by the development of recreation facilities at the county or city level.

(d) Grand Rapids Subarea. The Grand Rapids Subarea contains a varied assortment of resources with potential for recreation use. Among them are Lake Michigan, together with several State parks, natural lakes, good reservoir sites and broad river valleys.

1. Needs. Needs for developed land in the Grand Rapids Subarea amount to 14 acres of swimming beaches, 75 acres of boat launching and parking areas, 98 acres of camping area, 71 acres of parking area, and

8100 acres of water surface by 1985. There is no demonstrated need for picnicking, since Kent County has developed extensive areas for this activity. However, some picnic facilities should be included in new developments to provide a well balanced facility. Although they were not calculated individually, needs for other activities exist in substantial quantities.

2. Priorities. First priority should be given to completion of the development of the P. J. Hoffmaster State Park on the Lake Michigan shore and to the acquisition of access sites on those inland lakes that have potential for recreational use.

Second priority should be given to the initiation of development of the valley preserve system along the Grand River, upstream from Grand Rapids. This system should be extended both upstream as need dictates and downstream as need and water quality permit.

The construction of two reservoirs should receive third priority. They are the Rogue River Site, Site No. 19A, and Sand Creek Site, Site No. 74.

3. Proposed Development.

a. Existing Recreation Areas and Lakes. The J. P. Hoffmaster State Park can support expanded development in addition to that already included in programmed supply. Therefore, expansion of recreation facilities in this park area should continue until its full potential is reached. This area can provide additional opportunities for swimming, picnicking, and other related land-based activities. Public access sites should be developed on all lakes where such facilities are not now available and where a significant amount of boating and fishing opportunities can be obtained.

b. Valley Preserves. A valley preserve system should be initiated and developed upstream from Grand Rapids. This system should be extended into the urban area as far as is practical. The first phase of this program should continue upstream for a distance of at least 10 miles. When the Rogue River Reservoir is built, the valley preserve system should be extended from the Grand River Valley

up the Rogue River to the recreation area on this reservoir. A valley preserve system in this area could provide opportunities for swimming, boating, camping, picnicking, and other land-based activities. If swimming facilities cannot be developed along the river banks, such facilities can be developed adjacent to the stream. Boating opportunities could be increased by the construction of low head dams where consistent with the salmon program of the Michigan Department of Natural Resources.

c. New Reservoirs. The Sand Creek Reservoir would be located about six miles west of the City of Grand Rapids. It would service the Grand Rapids Metropolitan Area and would provide a full range of recreational activities.

The structure for this reservoir would be located in Section 22, T7N, R13W, on Sand Creek in Ottawa County. At an elevation 660 feet, the pool would contain about 1470 acres. It would be used for recreation, fish and wildlife.

The land around this proposed site is sloping to strongly rolling with dominant slopes ranging from 4 to about 12 percent. The land is well adapted for recreational development. Much of it is in pasture with small areas of interspersed woodlands. In addition to land for the impoundment, about 3000 acres of land should be acquired for the development of recreation area.

The Rogue River site would be located about three miles northwest of the City of Rockford and about ten miles north of Grand Rapids. It would service the Grand Rapids and Muskegon Metropolitan areas as well as numerous smaller communities. It could provide a full range of recreational activities.

The structure for this reservoir would be located in Sections 22 and 23, T9N, R11W on the Rogue River in Kent County. At an elevation of 735 feet, the pool would contain about 3300 acres. It would be used for recreation, fish and wildlife.

The land around this site is undulating to rolling with dominant slopes ranging from 3 to about 10 percent. It is well adapted for recrea-

tional development. At the present time, most of it is in pasture with some woodland, although some of it is cropped and some is idle. In addition to the land for the reservoir, about 4000 acres of land should be acquired for the recreation area.

4. Amount of Development. The following development is suggested for each of the resource areas proposed for development in this Subarea.

Resource Area	Acres of Developed Land					Acres of Water Surface
	Swimming	Boat Access	Camping	Picnicking	Parking	
Hoffmaster State Park	20	--	--	20	37	-----
Public Access on Lakes	--	10	--	--	--	-----
Valley Preserve System	3	5	10	10	8	-----
Sand Creek Reservoir	8	6	30	20	17	1,470
Rogue River Reservoir	5	4	30	20	12	3,300
Total	36	25	70	70	74	4,700

5. Percent of Needs Satisfied. The proposed level of development would satisfy about 53 percent of the boat launching and parking needs, about 71 percent of camping needs, about 72 percent of the parking needs, and about 58 percent of water surface needs and would provide a surplus in swimming. The picnicking would be in excess of needs, but some picnic facilities are needed on the new areas to provide a balance of activities.

(e) Northeast Subarea. Opportunities for the development of recreational facilities in this subarea are very limited. There are very few natural lakes, no major flood plains, no State parks, very few local parks, and very limited opportunities for the development of water surface area. Therefore, some of the needs prorated to this subarea will probably have to be satisfied in other adjacent areas.

1. Needs. Needs for acres of developed land in the Northeast Subarea amount to 45 acres of swimming beach, 72 acres of boat launching and parking, 183 acres of camping, 237 acres of picnicking, about 16,600 acres of water surface, and 118 acres of parking by 1985. There also is a need for facilities for hiking, nature walks, and other activities, but they were not calculated individually.

2. Priorities. First priority should be given to the acquisition and development of public access on existing water surface areas, if they can support a significant amount of recreational usage.

Second priority should be given to the construction of the Lookingglass Site, Site No. 148; the Grub Creek Site, Site No. 149; and the Bear Creek Site, Site No. 109.

Third priority should be given to meeting some of the needs of this subarea in adjacent areas where there is substantially greater opportunity for the development of recreational facilities.

3. Proposed Development.

a. Existing Lakes. Public access sites should be acquired and developed on existing lakes to the limit that the few lakes in this subarea can support additional recreational activities.

b. New Reservoirs. The Lookingglass and Grub Creek Sites are located about three miles southeast of the Village of Morrice and about 22 miles east of Lansing. They would service the Lansing and Flint Metropolitan Areas and many smaller communities in the immediate vicinity.

The structure for the Lookingglass Reservoir would be located on the headwaters of the Lookingglass River in the northern part of Sections 20 and 21, T5N, R3E, in Shiawassee County. At an elevation of 870 feet, this structure would create a pool of 430 acres of water. These reservoirs would be used for recreation, fish and wildlife.

The land in the vicinity of these two structures varies from undulating to strongly rolling with slopes ranging from 3 to more than 15 percent. It has substantial aesthetic qualities for recreational

development. In addition to the need for the reservoirs, at least 2000 acres of land should be acquired for the development of recreational facilities. The land between the two impoundment areas should be acquired to tie them together into a common recreation facility.

The Bear Creek site would be located about 7 miles west of the City of Owosso and about 17 miles northeast of the Lansing Metropolitan Area. It would service the Lansing Metropolitan Area and many smaller communities in the immediate area.

The structure would be located in Section 26, T7N, R1E, on Bear Creek, a small tributary of the Maple River in Shiawassee County. The pool would contain about 280 acres of water. The area would be used for recreation, fish and wildlife.

The land around the impoundment is rolling to strongly rolling and is well adapted for development of recreational facilities. About 1000 acres should be acquired for the development of the recreation area.

4. Amount of Development. The following development is proposed for each of the resource areas considered in this subarea. Except for the water surface, the initial level of development on the proposed reservoir sites is approximately one-third of their maximum potential.

	Acres of Developed Land					Acres of
Resource Area	Swimming	Boat Access	Camping	Picnicking	Parking	Water Surface
Existing Lakes	--	5	--	--	--	-----
Bear Creek Reservoir	4	1	20	15	9	280
Lookingglass and Grub Creek Reservoir	5	4	40	40	16	930
Total	9	10	60	55	25	1,210

5. Percent of Total Needs Satisfied. The proposed level of development would satisfy only 20 percent of swimming needs, about 13 percent of boat launching and parking needs, about 32 percent

of camping needs, about 23 percent of picnicking needs, about 20 percent of parking needs, and about 7 percent of water surface needs. Many of the unmet needs will have to be satisfied in areas outside of this subarea.

(f) Basin Summary of Satisfied Needs. Total needs for developed land in the Basin amount to 161 acres for swimming, 355 acres for boat launching and parking, 682 acres for camping, 677 acres for picnicking, 447 acres for parking, and 56,000 acres of water surface. Of this total need, the following amounts are proposed for development in this plan.

	Acres of Developed Land					Acres of
Subarea	Swimming	Boat Access	Camping	Picnicking	Parking	Water Surface
Jackson	12	15	75	70	33	7,800
Lansing	20	13	92	145	63	4,200
West Central	18	47	188	158	57	5,340
Grand Rapids	36	25	70	70	74	4,720
Northeast	9	10	60	55	25	1,200
Total	95	110	485	498	252	23,260

The development of these facilities would provide for about 59 percent of all swimming needs, 30 percent of all boat launching and parking needs, about 71 percent of all camping needs, about 73 percent of all picnicking needs, about 56 percent of all parking needs, and about 42 percent of all water surface needs. The unmet swimming needs do not include the 33 percent of total swimming need allocated to be satisfied in swimming pools. Some of the unmet swimming, camping, and picnicking needs could be satisfied by the development of additional facilities for these activities by local units of government or by the private sector.

(3) Supplementary Considerations.

(a) Role of Local Governments. As in the past, local units of government - counties, townships, and cities - will need to continue their role of providing a substantial portion of the total

needs for development of recreational facilities. Local governments should assume much of the responsibility for the development of the valley preserve system and of recreational facilities on existing lakes. In addition to this role, they should develop the necessary facilities to satisfy the unmet needs remaining from the Basin Plan except for water surface area. The cost of developing water surface area normally would be beyond the capacity of local governmental entities.

(b) Role of the Private Sector. The private sector should be strongly encouraged to provide facilities to meet some of the additional needs also. At the time of the inventory of existing recreational facilities, the private sector was providing nearly 20 percent of all camping spaces in the eleven-county area. It also provides a small but unknown amount of swimming and picnicking facilities.

The private sector can be expected to provide recreational opportunities and facilities only where the economic return justifies the risk of the investment. The private sector should be encouraged to continue to supply camping, swimming, picnicking, and related opportunities for the public. It is believed that many people would pay a reasonable fee to swim in natural lakes where good beaches had been developed and where water quality was acceptable. Picnic facilities can readily be provided at a nominal cost in association with swimming facilities. Those who own suitable lands on private lakes should be encouraged to develop them for public use.

Another area where the private investor can function effectively is the construction and management of boat marinas. If private investors can be encouraged to function in these areas, more public funds will be available for the development of those recreational facilities that do not attract the private investor.

(c) Preservation of Outstanding Resources. Land adjacent to rivers and streams often includes important plant and animal communities, structures of historical importance, and features of strong actual or potential aesthetic appeal. Indiscriminate or unplanned development of these lands may imperil important and sometimes irreplaceable natural and cultural resources worthy of preservation.

A study by the National Park Service revealed the presence of numerous archeological sites along the Grand River and its tributaries. Although funds are not now available to permit investigation of more than a small fraction of the sites, it is in the public interest that a significant and representative sample of the sites be preserved and eventually investigated.

Although the National Park Service study did not identify any unique plant or animal communities or other natural or cultural resources, it is nonetheless true that the river and stream valleys within the Grand River basin support a rich and varied wildlife population within a predominantly wooded setting.

The protection and preservation of these resources depends upon timely implementation of the valley preserves recommended by this report.

1. Wild, Scenic, and Recreational Rivers. There are no rivers in the Basin which have been recommended as wild, scenic, or recreational rivers. However, the Coldwater River, a tributary of the Thornapple River, is noted chiefly for its clean, cold waters rippling over beds of gravel, its wooded stream banks, and rolling hills - some wooded - rising to the north and south. The lower part of the Flat River also flows through some very scenic landscapes. While these rivers do not possess the unusual characteristics of a wild, scenic, or recreational river by national standards, they have certain qualities which need to be considered for preservation by the State for local needs.

2. National and State Trails. The North Country Trail is proposed to cross the Grand River basin along the Lake Michigan shore in western Ottawa County. An alternate route proposed for study passes north and south through the eastern parts of Jackson and Ingham Counties and the central part of Shiawassee County. As the valley preserve concept is envisioned, a continuous trail system should be developed from the Sandstone Creek Reservoir, northwest of Jackson, along the Grand River Valley to its confluence with Lake Michigan. This trail could be connected with the alternate route of the North Country Trail in eastern

Jackson County when that one is completed. If this trail were connected with Detroit through the Huron River Valley, it would provide an excellent cross-State trail, either connecting or passing many of the principal population centers of the State.

(d) The Role of Aesthetics. Site planning on each of the proposed recreation areas should be accomplished in a manner to preserve as much of the natural beauty of the recreation area as possible. Since wooded areas are limited in extent, they should be protected from excessive traffic. Intensive use areas should be located some distance from unique areas of biological life. Where areas are deficient in shade, trees should be planted. In general, any reasonable measure that will protect or enhance the aesthetic qualities of recreational areas should be applied.

(e) Alternatives Outside of the Basin. Many recreational opportunities have been developed on lakes and rivers to the north of the Grand River basin. However, over the last few years, many of these facilities have been crowded beyond their capacity, especially for camping and boating. Additional water surface could be made available on some of those lakes presently without public access. Opportunities for camping, picnicking, hiking, and related land-based activities could be developed in State and National forests, but most of them have only limited water surface. However, the potential of each of them should be developed to its full capacity as need arises within the area or as unsatisfied needs are transferred from overcrowded areas.

Recreational facilities to the south and east are already used beyond their capacity. There appears to be little or no opportunity to satisfy a portion of the Grand River basin needs in this general direction.

The Lake Michigan shore presents excellent opportunities for the development of swimming, camping, picnicking, trails, and other related activities. However, except for the Grand Rapids Subarea, this resource is too far removed from the subareas to serve day-use needs effectively.

In addition, much of the Lake Michigan shoreline is privately owned in small parcels as residential property, especially in the southern part of the State; thus, the acquisition and development of this resource is costly and limited. This resource base serves large quantities of week-end and vacation users who come into the area from the east and south.

(f) Supporting Programs. There is no single solution that will relieve the water shortage during the recreation season. All measures that might make more water and other facilities available should be explored and included in a recreation plan. A number of measures are available to support and strengthen the carrying capacity of existing and new facilities. These measures include both physical and regulatory practices which, if applied vigorously to protect and improve water quality, would increase the efficiency of the use of water resources. Such measures should be established by the proper governmental entity where they are feasible, and they should be administered unequivocally to prevent development which would impair the aesthetic and recreational values of streams and lakes.

1. Water Quality Control. The effectiveness of any recreation plan is directly tied into the quality of water available for use. Any area of water lost through pollution reduces the supply by that amount and increases the pressures for use on an already deficient supply of recreational facilities. Water can not be considered available for recreation use unless it is of suitable quality. Minimum quality standards permit partial body contact, but the goal should be a quality of water that will permit whole body contact. There are two independent qualities which must be assumed in recreation waters: the absence of health hazards and desirable aesthetic qualities.

Pollution can affect recreation activities in several ways. Swimmers and water skiers coming in direct contact with the water are subject to illnesses caused by pathogenic organisms from human wastes. Turbidity caused by sediments or algal growth increases risks to swimming by reducing visibility under water. Contact with or ingestion of chemical wastes,

pesticides, and similar products can cause serious injury to swimmers and others in such waters. The boater's primary concern is physical damage to equipment by floating debris or chemical wastes.

All water-dependent and water-enhanced activities are adversely affected by visible floating, suspended, or settled solids arising from the disposal of sewage or garbage; sludge banks; slime infestations; heavy growths of attached plants or animals; blooms of high concentration of plankton; discoloration or excessive turbidity from sewage, industrial wastes, or even natural sources; the evolution of dissolved gases, especially hydrogen sulphide; visible oil or grease, including emulsions; surfactants that foam when water is agitated or aerated; and excessive temperatures that cause high rates of evaporation and cloudiness over the water.

Recreation is adversely affected by all improperly treated municipal and industrial wastes. Waters returned to streams or lakes from sewage treatment plants usually contain pathogenic organisms and/or other polluting materials. In addition, waste-waters commonly have offensive odors, tastes, or turbidity, which limit the aesthetic value as well as the direct uses of water. Solid wastes are often discarded or stored in any place where they can degrade water.

Many private residences are located on or near the shores of lakes and banks of streams in the Basin. Most of them are served with individual, inefficient sewage treatment systems that permit sewage wastes to seep into adjacent waters. Such pollutants commonly enter waters used for recreation or having potential for recreational use and degrade them below safe limits.

Agriculture is responsible for several types of pollutants such as sediments resulting from soil erosion, residues from pesticides, and the leaching of nutrients from animal wastes and soils. Sedimentation commonly reduces the quality of water both physically and chemically. Land is often put to those uses for which it is not well adapted; frequently land and

water conservation practices are not adequately and properly applied.

The control of residues from pesticides and leaching of nutrients from animal wastes and soils presents an unsolved problem. A rapid acceleration in research is needed to solve these problems before they become insurmountable.

The construction industry permits substantial quantities of soil sediments to enter water courses near construction areas. They make little effort to apply proven control measures to reduce this source of sediments to a minimum. They have failed to cooperate in evolving new techniques to control this source of pollutants more effectively.

2. Zoning. Zoning can be an effective tool when it is appropriately and impartially applied. Two types of zoning are available: (1) zoning of land use, and (2) time zoning.

Zoning of land use is designed to control uses to which land can be put. Intensive development of cottages and residences along streams and lakes commonly causes a severe deterioration of water quality. The proper application of zoning has not been used to control the degree of development on and near the shorelines. Complementary regulations, such as controls on the use of septic tanks, subdivision regulations, and housing codes, controlling the disposal of waste water have been little used by the appropriate agency to protect the quality of water.

All too frequently there is a pressure by private individuals, groups, or institutions to develop flood plains for residential, commercial, or industrial uses and then to request protection of such investments with expensive dams and channel improvements built by the government. The zoning of flood plains for recreational and other compatible uses subject to only limited or no damage by flooding is an alternative to urban development. Many recreational facilities are not subject to intensive damage from flooding. The State of Wisconsin has enacted legislation that requires counties to establish land use controls on flood plains and lake frontages. The State will establish such controls for those counties that fail to respond within a given time period. Such legislation in this State would

control undesirable development on flood plains and lake shores and would permit the effective development of a large recreational complex extending along the Grand River Valley as the needs for recreation increase through coming decades.

Time zoning is the establishment of regulations to control the time of day that recreators can participate in certain water-based activities, such as water skiing. Such measures are useful to reduce or eliminate conflict among various uses and tend to increase the total opportunity for participation in recreation activities on a given area of water.

3. Water Re-use. If it is properly treated, water can be used over and over again by industries and municipalities. Careful accounting of water usage should be maintained to ensure optimum availability of fresh water in surface and ground water supplies.

(4) Scale of Development. The scale of recreation development set forth on reservoir sites in the Plan of Development represents approximately one-third of the ultimate capacity of these facilities. The development of additional recreational facilities in post-1985 would satisfy a substantial part of additional needs as they arise.

On existing State Parks, the scale of development is designed to bring these facilities to their ultimate capacity as now planned by the State of Michigan.

Where public accesses are developed on natural lakes, they could be expected to reach their safe ultimate capacity for water-based activities within a few years.

The development proposed on the valley preserve system would represent only a small beginning of the ultimate potential of a basin-wide system. This system like the proposed reservoirs could satisfy a vast amount of recreation needs in the post-1985 period.

Table IV-13 shows the initial and ultimate levels of visitation that could be expected on these proposed recreation developments for the eight activities used in this study.

Table IV-13

Levels of Initial and Ultimate Visitation

Proposed Recreation Development	Reservoir Number	Visitation in Recreation Days Initial (1985)		Ultimate	
Rogue River	19A	286,000		1,669,000	
Duck Creek	25	287,000		746,000	
Prairie Creek	42	302,000		912,000	
Fish Creek	47A	340,000		1,159,000	
Portland	51	356,000		1,121,000	
Doan Creek	59	291,000		883,000	
Sandstone Creek	62	886,000		2,275,000	
Sand Creek	74	339,000		1,209,000	
Bear Creek	109	191,000		456,000	
Lookingglass and Grub Creek	148 and 149	369,000		1,107,000	
No Name Creek	180	245,000		596,000	
Subtotal			3,892,000		12,133,000
Hoffmaster State Park		566,000			
Ionia Recreation Area		153,000			
Newaygo State Park		165,000			
Sleepy Hollow		346,000			
Waterloo Recreation Area		51,000			
Yankee Springs		190,000			
Lake Access, West Central Subarea		92,000			
Lake Access, Grand Rapids Subarea		92,000			
Subtotal			1,655,000		
Valley Preserve (Grand Rapids)		177,000		875,000	
Valley Preserve (Lansing)		37,000		210,000	
Subtotal			214,000		1,085,000
Total			5,761,000		13,218,000

8. FISH AND WILDLIFE

a. Magnitude of Future Net Demands. Resource developments obviously must be located near, or preferably in, the subareas where greatest net demands are expected. The magnitude of projected Grand River basin needs, as expressed in user-days in Tables II-25 and II-26, may be considered minimal. Net demands could have been developed, with reasonably logical models, which would provide a great variation in demand estimates. The method chosen, which has been described in detail in Appendix K, resulted in the most conservative estimates of demand of those under consideration.

This approach assumed a stable fisheries base and a decreasing hunting base related to an increasing demand for these experiences, with the results adjusted for expected Basin pressures, rather than planning for local demands which quite likely will be exerted and met outside the Basin. Fish and wildlife developments within the highly populated Grand River basin can be expected to increase, but not to the degree where total in-basin demands could be fully satisfied without having to cross basin boundaries. This study will provide guidance, encourage and stimulate additional development, and define goals; but one cannot assume that utopian conditions will be provided for the hunter, fisherman, or outdoor recreationist in the foreseeable future in the Grand River basin.

b. Selection of Proposed Developments. Each agency whose program could affect existing or could create future basin fish and wildlife habitat was contacted and requested to give estimates of their projected construction or management plans to the year 1980. The Michigan Department of Natural Resources and Michigan State University provided information or analysis on recreation plans through 1980. Potential reservoir sites were identified by the Michigan Water Resources Commission; Detroit District, U. S. Army Corps of Engineers; Federal Power Commission; U. S. Soil Conservation Service; and the Tri-County (Lansing Subarea) Regional Planning Commission.

A sophisticated screening process was developed to select from these proposed sites and associated lands, those best suited for meeting future fish and wildlife demands using the following parameters:

(1) Biological considerations. Reservoir sites were considered from both a positive and a negative biological viewpoint. Habitat existing in the proposed reservoir basin was assessed against what the site might offer if developed.

Factors which excluded or radically devaluated the potential sites included: inundation of streams having good trout, smallmouth bass, or walleye fisheries; potential inundation of unique natural areas, State game areas, recreational areas, or parks; and streams having great potential for future anadromous fishery "runs". Discussions with the Michigan Department of Natural Resources were instrumental in judging the comparative existing and potential qualities of potential sites.

Other factors which received consideration in evaluating and screening structure potential were the existing and expected water quality of the source stream, as well as size, depth and expected use of the potential reservoir's waters and associated lands. Subareas having the greatest projected net demands and those having reservoir sites with the best fish and wildlife potential were not always one and the same. Because of this, consideration had to be given to developing sites in a given subarea, which would satisfy demands generated in an adjacent subarea.

(2) Sociological considerations. There are numerous sociological considerations inherent in our methodology for projecting future hunting and fishing demands. The initial factor for grading potential sites was the projected magnitude and source of need. Within this framework, access to potential sites from areas of demand and the spatial distribution of existing developments were important considerations. Conflicting uses by other sources of demand also received consideration. Potential sites in areas devoid of water habitat were accorded high priority; while sites lying near or beyond developed areas, remote from projected demands, received less attention.

(3) Economic considerations. A number of potential sites have little probability of being developed because of restraining economic considerations. Factors which would usually push development costs beyond favorable benefit/cost ratios include: (1) Relocations (residential and

industrial developments, sewage treatment plants, railroads, major highways); (2) Unfavorable topography of site (long or high dam, low ratio of acre feet to surface acreage, poor flow reliability of tributary streams); and (3) Other physical factors which would result in higher costs than benefits for site development.

c. Generalized Solutions for Basin Problems. There are two principal approaches to providing the opportunity needed throughout the Grand River basin: one involves increasing utilization of existing resources; and the other, developing new sources of hunting and fishing opportunity.

(1) Increased utilization of existing resources. A great deal of water habitat is degraded through the effects of industrial, municipal, and agricultural pollution. It is imperative that rehabilitative measures be taken on certain of these waters before they become completely unacceptable to fish life. This problem would be compounded by increasingly insufficient treatment facilities or practices and ever increasing costs for providing adequate treatment. New and improved legislation embodying stronger penalties for violation of pollution laws is needed. Water quality criteria must be enforced to meet the requirements of a diversified aquatic community encompassing all life history stages. In setting standards for aquatic life, the Michigan Water Resources Commission has stated that it is important that recommendations consider: "the most sensitive species, the intolerant developmental stages, the synergistic effects of combined stresses, the long-term effects of sustained low-level toxicity, and many other factors". If specific waters are classified far below their capabilities for supporting aquatic life, many existing and potential sources of fishing opportunity will be lost or severely impaired.

Fisheries and certain wildlife populations are dependent upon the quality of their aquatic environment. The Michigan Department of Natural Resources feels that, "Recent improvement in pollution control laws, techniques, and enforcement tend in the directions of better water quality and, consequently, better wetland wildlife habitat. In spite of the advances, a major effort accompanied by large sums of money will be necessary before this problem is solved. Increased urbanization, expanded and more widespread industry, and more general use of toxic agricultural chemicals tend to complicate this problem".

Programs are needed to prevent or remedy unwarranted degradation of existing fish and game resources through dredging, filling, and other land development practices. According to the Michigan Department of Natural Resources, "Land development on or near water has expanded tremendously with little or no statewide controls which has resulted in serious reduction of quality fishing waters." Wetlands wildlife habitat, once abundant throughout the basin, has decreased continuously during the past century. As in the past, structural measures for improved drainage and reduced flooding are often necessary. In other cases, such improvements are not warranted and water management is best achieved by holding water on the land through improved land treatment and small reservoirs.

Developments designed primarily for the other purposes can often provide secondary or indirect benefits by creating wetlands habitat. For example, road or highway construction, shallow sediment pools in Soil Conservation Service small watershed projects, and farm pond construction all can provide habitat of value to waterfowl and other aquatic birds and mammals.

Prociding access to existing opportunity is a major consideration in a recreationally oriented state. The Michigan Department of Natural Resources states:

> *"Michigan has the largest number of registered boats in the Nation---487,000 as of 1971. Studies of boating trends indicate the total number can reach 800,000 by 1980. This demand cannot be met without chaos along the waterfront and troublesome problems for boaters and boat businesses unless a vigorous public program is pursued."*

According to Department surveys, there were 6300 acres of water throughout the basin in 1966 which needed access developments. The Department is actively undertaking an access acquisition and rehabilitation program which is designed to keep pace with existing and future demands for angler access.

Fishery management programs in future years should provide continuing better use of existing resources and direct attention to areas of effort offering greater return to the sportsman. Research on trout stocking

sizes, stocking rates, and angler catch has shown that by stocking greater numbers of sublegal trout rather than a few large trout, the angler can expect to catch greater numbers of legal-sized trout. This method of "put, grow, and take" is also more economical. Warmwater fishery programs are also receiving additional consideration. Northern pike spawning marshes will be developed. Fishing laws are being liberalized wherever biological data indicate laws are too restrictive. The chemical eradication of problem fish populations, with a subsequent restocking with desirable fish, has been an expanding program. Partial treatments have been used for thinning over-abundant pan fish populations to encourage growth and thereby produce more catchable fish. Stunted pan fish populations are a major problem in Grand River basin lakes.

The future course of the commercial fishery in the basin is likely to depend upon the Lake Michigan fishery. In this regard, the Grand River system has been identified as a contributor of sea lampreys to the lake. Bureau of Commercial Fisheries biologists have carried out chemical control work on several of the lower tributaries of the Great Lakes. If no other factors are limiting, present lamprey control work will eventually return Lake Michigan commercial fishery values to levels comparable to those existing before lamprey parasitism. Also, the large populations of alewives currently in the lake are expected to provide food supplies for increasing populations of lake trout and other important lake species.

The overall game management program also is providing and should continue to provide for increased use of existing wildlife resources. The soundness of an anterless deer season in southern Michigan is now accepted. The program has curbed certain deer management problems and has provided needed additional opportunity for the hunter. The mourning dove represents another wildlife species that could provide additional opportunity without additional cost or hunting acreage, merely by adding it to the game bird list.

Turkeys thriving in Allegan County, which lies partially within the Grand River basin, suggest that introductions might be successful elsewhere in the basin. Habitat similar to that in Allegan

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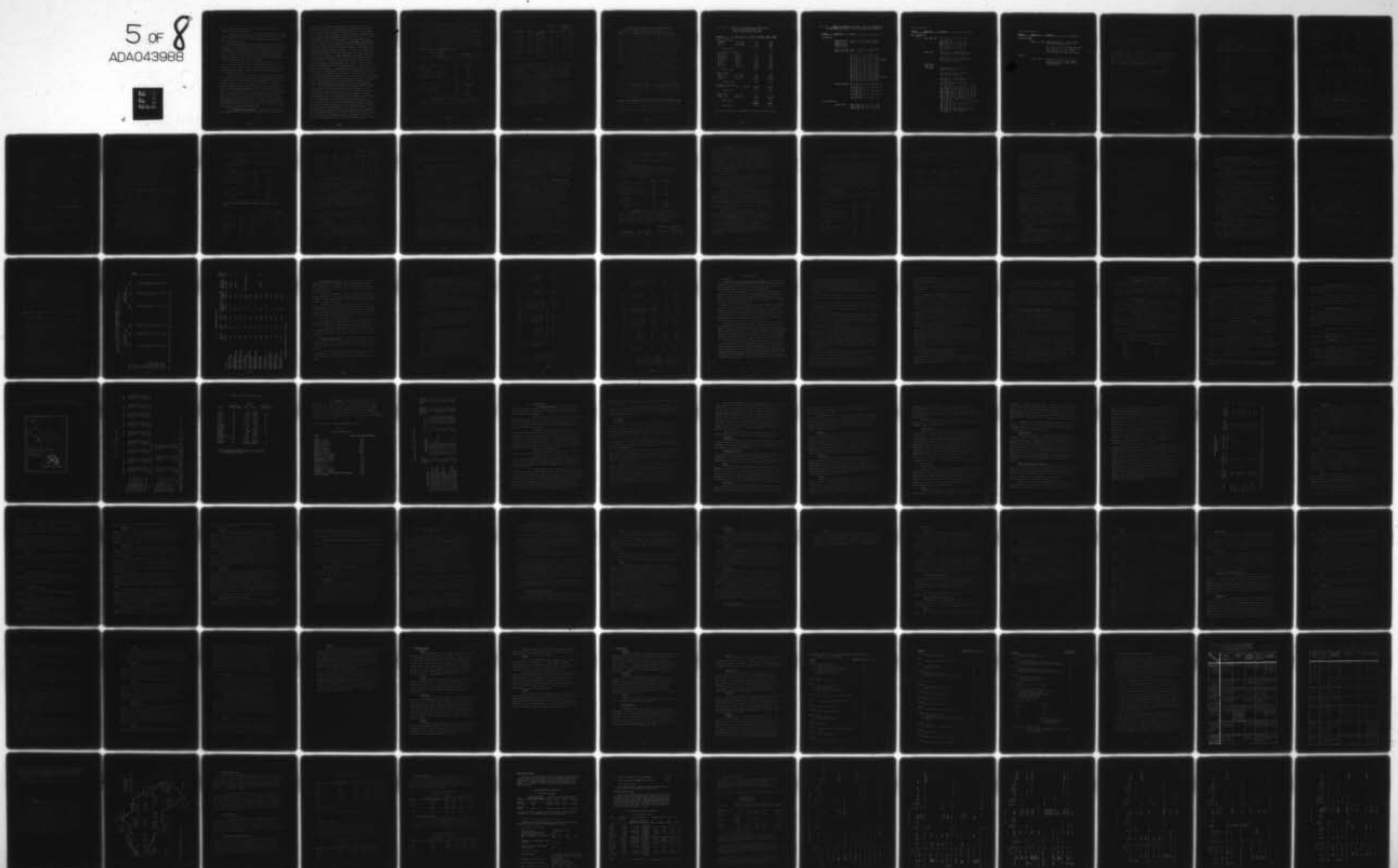

County also exists in Montcalm, Kent, and Barry Counties, with lesser acreages in other basin counties.

Continued efforts should be made to repeal bounty laws in Michigan. This antiquated system has no biological basis and is an unnecessary budget drain. Total cost of bounties in 1963 was $242,135, only $160 short of the recorded payment in 1961.

Habitat development has been accelerated on public game and recreation areas. Upland game populations have responded favorably to this type of management, which includes the creation of brushpile shelters, development of additional "edge", increased herbaceous plantings, and more tree and shrub plantings. The Williamston Plan Program and Federal Cropland Adjustment Program should have continued success in providing opportunity to the basin hunter, at little cost to the State.

Certain basin areas do not allow hunting on Sunday. If Sunday hunting were allowed throughout the basin, the worker's opportunity to go afield would be greatly enhanced. Huntable lands and species generally can support greater usage, and hunter participation would increase, with no additional State expense.

Applied research and development are vital to any progressive plan for meeting future fish and wildlife needs. Fishery studies, including those concerned with mortality and disease, sea lamprey control, cold and warmwater population dynamics, general creel censuses, age and growth analyses, limnology of lakes and streams, fish toxicants, and aquatic plant control, all are expected to provide answers that will create increased future use of existing habitat, with increased efficiency. Studies designed to aid in the management of future wildlife populations include those on the effects of pesticides and herbicides on wildlife, tracking wildlife movement through radiotelemetry, evaluation of hunter success resulting from game management measures, analysis of inventory and population estimation methods, studies of farmland deer herds, and surveillance of diseases such as rabies, lead poisoning, and botulism.

(2) <u>Development of new resources</u>. In some areas in the basin the fish and game habitat base available to the public could not support all

future fishing and hunting net demands even if optimum use of these lands and waters was realized. In these cases it will be necessary to develop or acquire new areas or introduce new stocks of hunting or fishing opportunity to support expected demands. There are several development programs now underway or being proposed that are expected to have an overall positive effect upon the Grand River basin sportsman. The program now receiving national attention is the introduction of coho and chinook salmon into Lake Michigan. If expectations are realized, and results do appear encouraging, utilization of this new resource should be tremendous. Approximately 40 percent of the Nation's population resides in the industrial midwest, which borders the Great Lakes. The Great Lakes comprise by far the largest bodies of fresh water in the world. These comparatively undeveloped segments of fisheries habitat now appear to have a new future with attendant benefits for basin anglers. The possible introduction of striped bass into basin waters also suggests another potential quality fishery. The striped bass and salmon have spawning habitat requirements that can be met by some streams in the Grand River Basin. If anadromous populations are established in Lake Michigan, the Basin angler should be able to fish spawning runs of salmon (fall) and striped bass (spring) near his residence. There may be certain stream obstructions that should be removed, if they are of no value, or fish passage devices built into the remaining structures to permit access to choice spawning areas. These programs will also require building or conversion of fish hatchery facilities to meet initial salmon or bass stocking requirements.

The construction of large and small reservoirs will be of benefit to many interests. The theory of multi-purpose developments is often sound; however, in practice, single-purpose units also merit consideration. Over-development can be as inexcusable as under-development. A variety of recreational experiences can be provided by a complex of single or dual-purpose developments on a less cluttered and more easily managed scale, than by trying to plan each unit of the group as "all things to all people." For example, a reservoir constructed to provide fishing opportunity requires optimum water depth during the summer, while a waterfowl reservoir is often best managed with low water levels during the summer to promote vegetation and increasing water depths in the fall to attract waterfowl and to partially flood food patches. Multi-purpose reservoirs often provide a spectrum of conflicts and problems to the fish and wildlife manager, which often appear

impossible to resolve. Some impoundment uses that are better developed on a single or dual-purpose basis are wetland or waterfowl impoundments, northern pike spawning marshes, and small fishing impoundments.

Construction of larger reservoirs in the Basin could possibly provide additional commercial fishing opportunity. Commercial operations in these waters will depend largely on the availability of markets and on legal restrictions. However, should carp and other non-game species become established in sufficient numbers, occasional commercial removal under supervision of the Michigan Department of Natural Resources might be desirable. This possibility should be considered in future planning of water resources development in this Basin.

d. Grand Rapids Subarea

(1) Projected plans. The acreage and preliminary use estimates, provided by projected State, county, and local fish and wildlife developments in the Grand Rapids Subarea for the interim 1965-1980 are:

Hunting	Acres	Net Days Use
Additional to Existing Game Areas	380	390
New Game Area	1,400	1,500
Scarce (Waterfowl) Habitat	200	130
State Parks or Recreation Areas	950	980
Secondary Waterfowl Habitat	320	200
Total	3,250	3,200

Fishing	Acres	Net Days Use
Farm Ponds	250	17,500
Small Fishing Impoundments	25	880
Fishing and Park Lakes	44	1,500
Total	319	19,880

(2) Reservoir sites. Projects proposed and ultimately considered in this study, which would be of greatest benefit for meeting fish and wildlife demands in the Grand Rapids Subarea, are listed below:

Site Name & No.	Stream	Dam Site	Summer Pool Acres	Summer Pool Elev.	Net Days Use (Preliminary Estimate) Hunting	Net Days Use (Preliminary Estimate) Fishing
Rockford (19)	Rogue	T9R11, Sec. 25	3,800	740	20,700	83,000
Bear Creek (21)	Bear	T8R10, Sec. 30	720	700	1,700	25,900
No Name (278A)	No Name	T9R10, Sec. 31	150	800	330	9,000
Sand Creek (74)	Sand	T7R13, Sec. 27	1,470	660	2,900	40,700
Ravenna #2 (16)	N. Br. Crockery	T9R14, Sec. 11	380	680	760	14,200
Bass Creek (316)	Bass	T7R15, Sec. 25	230	615	500	9,500
Deer Creek (18)	Deer	T7R14, Sec. 1	710	620	1,300	20,400
Norris Creek #2 (64)	Norris	T9R15, Sec. 21	430	640	760	15,500
Rio Grande Creek (321)	Rio Grande	T9R14, Sec. 22	135	658	300	7,800

(3) Discussion. The Grand Rapids Subarea is estimated to need 84,000 additional angler-days opportunity by 1980; 236,300 by 2000; and 373,300 by 2020, to satisfy increasing demand (Table II-25). An additional 117,700 hunter-days use will be required by 2000, and 281,100 days-use will be needed by 2020, over that available in 1960 (Table II-26). These requirements do not include demands by subarea residents which must presently be met outside of the subarea.

The Michigan Department of Natural Resources plans to stress acquisition of public hunting lands in southern Michigan: "Plans call for gradual extension of ownership in present southern Michigan Game Areas where the State now owns only 45 percent of the land within boundaries. Three to five percent of these lands are proposed to be bought each year in a long-range program." Lands acquired throughout the Basin can provide deer, waterfowl and small game hunting. Michigan Recreation resource planners estimate that 4750 acres will be added to existing Basin game areas and 18,000 acres will be purchased as new Basin game areas by 1980.

The ratio of subarea acreage to total basin acreage was used to allot the projected Basin acquisition acreage to each subarea. The 380 acres assigned to the Grand Rapids Subarea could be added to Grand Haven, Rogue River, Cannonsburg, or Lowell State Game Areas. The ultimate or goal acreage (Table IV-14) for any of these areas would not be met, even if the entire 380 acres were purchased at a single area. Selection of areas of acquisition will depend on the State's management plans for each area, the availability of desired acres at particular areas, and acquisition costs. Indications are that an additional 1400 acres of game area lands will be acquired to develop new public hunting areas in the Grand Rapids Subarea prior to 1980 if traditional acquisition patterns are adhered to. Game areas could be developed at minimum costs in conjunction with proposed Federal reservoir plans. There are several possible sites west of Grand Rapids, located in Ottawa County, which would be desirable for new game area development.

Projected purchases of scarce waterfowl habitat are expected to total 200 acres in the Grand Rapids Subarea, and 1400 acres throughout the entire Basin. Selection of a potential area is governed by its relation to existing waterfowl habitat and its availability for purchase. Scarce wetland habitat may also be provided by water control structures regulated specifically for wetland management. These types of impoundments are scheduled to be constructed at State game areas through the Basin. The Grand Haven, Rogue River, and Cannonsburg areas are scheduled for wetland development (Table IV- 15) in the Grand Rapids Subarea. If these impoundments are built at comparable size to those previously constructed by the State, they will be of a size (average five acres) which facilitates management.

State and Recreation Area lands are estimated to increase by 12,000 acres throughout the Basin by 1980, of which 950 acres have been tentatively allocated to the Grand Rapids Subarea. If hunting is allowed in future years on this land, potential usage could be significant in meeting future planning area demands. The assumption was made that fall hunting would be permitted on these new park lands, at least until the year 1980.

Table IV-14 A SUMMARY OF STATE-OWNED PUBLIC HUNTING AREAS, WITHIN THE GRAND RIVER BASIN, 1965, LISTING PRESENT AND GOAL ACREAGES

Location	Name of Area	Present Acreage	Goal Acreage
Grand Rapids Subarea			
Ottawa Co.	Grand Haven	675	3930
Kent Co.	Cannonsburg	1327	3294
Kent Co.	Rogue River	5180	8176
Subarea Total		7182	15400
West Central Belt Subarea			
Montcalm Co.	Flat River	8949	15417
Montcalm Co.	Stanton	3305	6853
Montcalm Co.	Langston	2705	5500
Montcalm Co.	Edmore	1661	4240
Ionia Co.	Portland	1499	5275
Ionia Co.	Lowell	1850	4126
Barry Co.	Barry	14199	26011
Barry Co.	Middleville	2890	8030
Subarea Total		37058	75452
Lansing Subarea			
Clinton Co.	Rose Lake	3204	4760
Clinton Co.	Maple River	4842	11104
Ingham Co.	Dansville	4050	4931
Subarea Total		12096	20795
Northeast Fringe Subarea			
Gratiot Co.	Gratiot - Saginaw	12629	20070
Subarea Total		12629	20070
Jackson Subarea			
Jackson Co.	Sharonville	2251	5583
Jackson Co.	Waterloo	15612	15612 1/
Subarea Total		17863	21195
Basin Total		86828	152912

1/ A goal acreage was not available for the Waterloo Recreation Area.

Table IV-15 A SUMMARY OF WATERFOWL IMPOUNDMENTS PROPOSED FOR DEVELOPMENT ON STATE GAME AREAS PRIOR TO 1980, GRAND RIVER BASIN, MICHIGAN

Subarea	Game Area	Location
Grand Rapids		
	Grand Haven SGA (water control structure with pumping station)	Dragline work and possible diking, no plans have been made to date.
	Rogue River SGA Spring Creek Dam	Rogue River Game Area engineering report available, 70 acres.
		SW of NE, Sec. 2, T 10 N, R 12 W
		NW of SW, Sec. 1, T 10 N, R 12 W
		NW of NW, Sec. 11, T 10 N, R 12 W
		SW of NW, Sec. 12, T 10 N, R 12 W (2 dams)
		NE of SW, Sec. 13, T 10 N, R 12 W
		NW of SE, Sec. 13, T 10 N, R 12 W
		SE of SE, Sec. 13, T 10 N, R 12 W
		NW of NW, Sec. 24, T 10 N, R 12 W
		NW of NE, Sec. 24, T 10 N, R 12 W
		SE of NE, Sec. 23, T 10 N, R 12 W
		NE of SW, Sec. 23, T 10 N, R 12 W
		NE of SW, Sec. 24, T 10 N, R 12 W
		SW of SW, Sec. 24, T 10 N, R 12 W
		SW of SE, Sec. 24, T 10 N, R 12 W (2 dams)
		NE of NE, Sec. 26, T 10 N, R 12 W
		SW of NW, Sec. 25, T 10 N, R 12 W
	Cannonsburg SGA	NE of SE, Sec. 29, SE of SW, Sec. 27, T 8 N, R 10 W
		SW of NW, Sec. 34, SE of NW, Sec. 34, T 8 N, R 10 W
		NE of SW, Sec. 33, SE of SW, Sec. 33, T 8 N, R 10 W
		NE of NW, Sec. 4, SE of NW, Sec. 4, T 7 N, R 10 W
		SE of NE, Sec. 4, T 7 N, R 10 W
West Central Belt		
	Langston SGA	NE$\frac{1}{4}$ of NW$\frac{1}{4}$, Sec. 27, T 11 N, R 8 W
		NE$\frac{1}{4}$ of NE$\frac{1}{4}$, Sec. 33, T 11 N, R 8 W
		SE$\frac{1}{4}$ of SE$\frac{1}{4}$, Sec. 28, T 11 N, R 8 W

Table IV-15 (Cont'd)

Subarea	Game Area	Location
West Central Belt (cont.)		
	Flat River SGA	SW of SE, Sec. 34, SE of SE, Sec. 34, T 9 N, R 8 W
		$NE\frac{1}{4}$ of $NE\frac{1}{4}$, Sec. 2, T 8 N, R 8 W
		$NW\frac{1}{4}$ of $NE\frac{1}{4}$, Sec. 2, T 8 N, R 8 W
		NW of NW, Sec. 2, T 8 N, R 8 W
		NW of SE, Sec. 1, T 8 N, R 8 W
		SW of SE, Sec. 2, T 8 N, R 7 W
	Barry SGA	Glass Creek, no specific plans have been made, some private land involved.
		Turner Creek, Barry State Game Area, some engineering plans which should probably be re-evaluated.
	Stanton SGA Three Lake Flooding	NE of NW, Sec. 2, T 10 N, R 6 W dam and dragline work
		Colby Lake Dam, Stanton Game Area, no plans have been made.
		NW of NW, Sec. 2, NW of NW, Sec. 2 (1 dam)
		SW of NW, Sec. 2, SE of NW, Sec. 2, T 10 N, R 6 W
		NW of NW, Sec. 3, SW of NW, Sec. 3, T 10 N, R 6 W (1 dam)
		NE of SW, Sec. 2, T 10 N, R 6 W (1 dam)
		NE of SW, Sec. 4, T 10 N, R 6 W (1 dam)
		$NW\frac{1}{4}$ of $SE\frac{1}{4}$, Sec. 5, T 10 N, R 6 W (1 dam)
		$NE\frac{1}{4}$ of $SW\frac{1}{4}$, Sec. 5, T 10 N, R 6 W (1 dam)
		$SE\frac{1}{4}$ of $SW\frac{1}{4}$. Sec. 5, T 10 N, R 6 W (2 dams)
		$SW\frac{1}{4}$ of $SE\frac{1}{4}$, Sec. 5, T 10 N, R 6 W (1 dam)
		$SE\frac{1}{4}$ of $SE\frac{1}{4}$, Sec. 5, T 10 N, R 6 W (2 dams)
		NE of NW, Sec. 7, SE of NW, Sec. 7, T 10 N, R 6 W (7 dams)
		SE of NW, Sec. 9, T 10 N, R 6 W (1 dam)
		NE of NW, Sec. 13, T 10 N, R 7 W
		NW of NW, Sec. 13 (1 dam)
		NE of NW, Sec. 24, T 10 N, R 7 W (1 dam)
		NW of NW, Sec. 24, SW of NW, Sec. 24
		SE of NW, Sec. 24, T 10 N, R 7 W (3 dams)

Table IV-15 (Cont'd)

Subarea	Game Area	Location
Northeast Fringe		
	Maple River SGA	Along the west side of US-27, diking and control structure needed.
		NE$\frac{1}{4}$ of SW$\frac{1}{4}$, Sec. 29, SE$\frac{1}{4}$ of NE$\frac{1}{4}$, Sec. 29 SW$\frac{1}{4}$ of NE$\frac{1}{4}$, Sec. 29, SE$\frac{1}{4}$ of NW$\frac{1}{4}$, Sec. 29 NE$\frac{1}{4}$ of NW$\frac{1}{4}$, Sec. 29, T 9 N, R 2 W Proposed future dike around open marsh.
Jackson		
	Portage Marsh	Waterloo Recreation Area, some private land must be acquired, this area is being studied at the present time for a PL-566 Project.

Secondary waterfowl habitat and the hunting it sustains will be provided by farm ponds, small fishing impoundments, and fishing and park lakes.

Projections of farm pond construction prior to 1980 have been extrapolated from annual county construction totals occurring from Fiscal Year 1963 through Fiscal Year 1966. Assuming that construction rates in Ottawa and Kent Counties continue at these derived rates through 1980, 250 acres of water will be provided by 500 subarea farm ponds. Farm ponds could satisfy an estimated 17,500 annual angler-days use. This figure does not include angler use of irrigation storage reservoirs, irrigation pits or regulating reservoirs. Most farmers and landowners enjoy the added rewards of managing their ponds for fishing. Whether or not the pond is opened to the public for fishing, the sustained construction of farm ponds will serve to reduce fishing intensity on public fishing waters.

About 1600 acres of State constructed small fishing impoundments and larger fishing and park lakes are programmed for basin development prior to 1980. This figure may become larger if projected programs are accelerated. In the Grand Rapids Subarea, at least an additional 70 acres of this type of habitat might be expected before 1980. Locations have not been selected, but smaller impoundment sites are listed in the Grand Rapids Subarea's proposed plans subsection. We assume that all reservoir developments will be provided with adequate access facilities to the impoundment and its tailwater.

The nine sites proposed for future development were selected from 20 potential impoundments in the Grand Rapids Subarea. Some of the sites do not presently have adequate flood control and allied benefits for immediate construction as multi-purpose projects, but they would provide immediate single-purpose fish and wildlife development. Many of the sites located near Grand Rapids will be developed by other interests if they are not acquired in the very near future. Recreation sites near this growing urban complex will increase tremendously in value with each passing year.

The Rogue River or Rockford Site, designated as Site 19, was selected as having outstanding potential for fish and wildlife development. Other participating agencies have also shown considerable interest in this site, enhancing its potential for multiple-purpose development. The dam site is located 1/2 mile north of Rockford, and approximately 10 miles northeast of Grand Rapids. From present data, the normal summer pool would be approximately 4,300 acres and the depth at the dam would be 46 feet. The Rogue River presently had anadromous fish potential, but it is questionable that this potential could be realized due to rapid industrial and residential development of its lower reaches. This potential reservoir would appear to have the water quality and depth necessary for considering landlocked kokanee salmon introduction supported by spawning areas in the upstream tributaries. Upland game habitat surrounding this reservoir and waterfowl areas within the reservoir area would provide considerable hunting opportunity.

The remaining eight sites all have potential for fish and/or wildlife development. Those having higher priority ratings should be considered before the sites are taken by other interests. Sites 21, 180 and 74 fall into this category.

The anadromous fish development program should have a considerable, but yet undetermined, effect on satisfying near-future (1980) angler demands in the Grand Rapids Subarea. All spawning runs passing into the Grand River Basin will pass through this subarea. The Lower Coldwater and Thornapple Rivers are expected to have especially suitable spawning habitat for anadromous fish populations in the Grand River basin.

e. West Central Belt Subarea Plan.

(1) Projected Plans. The projected fish and wildlife developments in the West Central Belt Subarea, for the interim 1965-1980, are listed below. The acreage and preliminary use estimates that would be provided by these developments are:

Hunting	Acres	Net Days Use
Additions to Existing Game Areas	2,100	2,200
New Game Areas	8,100	8,300

Hunting	Acres	Net Days Use
Scarce (Waterfowl) Habitat	370	230
State Parks or Recreation Areas	5,400	5,600
Secondary Waterfowl Habitat	360	220
TOTAL	16,330	16,550
Fishing		
Farm Ponds	320	22,400
Small Fishing Impoundments	41	1,400
TOTAL	361	23,800

(2) Reservoir Sites. The following reservoir sites were selected as having the greatest potential for meeting future fish and wildlife demands in the West Central Belt and surrounding subareas:

			Summer Pool		Net Days Use (Preliminary Estimates)	
Site Name & No.	Stream	Dam Site	Acres	Elev.	Hunting	Fishing
Sessions Creek (239)	Sessions	T7R7, Sec. 34	220	720	700	15,800
Prairie Creek (42)	Prairie	T7R6, Sec. 16	920	738	2,800	29,000
Fish Creek (47A)	Fish	T9R5, Sec. 35	2,300	747	16,400	65,700
No Name (238)	No Name	T7R7, Sec. 35	50	710	300	3,500
Duck Creek (25)	Duck	T5R8, Sec. 29	940	820	2,500	26,000
Muir (46)	Maple	T7R5, Sec. 9	2,300	644	19,400	15,000
Wonadoga (-)	Wonadoga	T1R7, Sec. 26	700	855	2,100	16,100

(3) Discussion. The West Central Belt Subarea has projected net demands of 36,300 angler-days by 1980; 219,200 by 2000; and 427,300 by 2020, in excess of the opportunity available in 1960 (Table II-25). Net demands for hunting will approach 70,000 days-use by 2000 and 154,100 by 2020 in excess of that which was sustained by 1960 opportunity (Table II-26). These figures exclude some of the demand from adjacent subareas which has been met by this subarea in past years. The subarea can be expected to encounter increasing demands from Grand Rapids, Lansing, and Jackson as their urban complexes grow.

The Michigan Department of Natural Resources has attained nearly one-half of its goal in developing public hunting acreage in the West Central Belt Subarea (Table IV-17). We expect this general trend will continue because the lands in this subarea are less intensively farmed and more suitable and less costly for game management development than in other subareas. State game areas located in this subarea are also easily accessible from population centers to the east, west, and south. If past acquisition trends are maintained, 2100 public hunting acres will be added to existing sites: i.e., Middleville, Barry, Portland, Lowell, Flat River, Stanton, Edmore, and Langston State Game Areas. Remaining goal acreage for these areas totals 38,400 acres (Table IV-17). The State's management plans for each area, the availability of goal acres at particular areas, and the per-acres cost will determine which areas will receive priority for acquisition.

Approximately 8100 acres of public hunting habitat could be acquired at new areas within the West Central Belt Subarea. Because of the subarea's wealth of good reservoir sites and the need for such sites in the near future, primarily from adjacent subareas, it is quite possible that new game areas could be acquired in conjunction with reservoirs.

Scarce waterfowl habitat purchases or developments are expected to approach 370 additional acres by 1980. Selection of a potential area is governed by its relation to existing waterfowl habitat and its availability for purchase. Small water control structures, constructed specifically for the benefit of wildlife and waterfowl, are scheduled for development at the Langston, Flat River, Barry, and Stanton areas in the subarea (Table IV-18).

Secondary waterfowl habitat and the hunting it sustains will be provided by farm ponds and small fishing impoundments. A total of 360 acres of habitat having secondary potentials for waterfowl are projected for development prior to 1980. Additional acreage would be provided by the construction of proposed reservoirs.

State Park or Recreation Area lands in the West Central Belt Subarea are estimated to increase by 5400 acres by 1980. The Ionia Recreation Area is expected to provide approximately 3300 acres of huntable land, or 60 percent of this projected figure.

Farm pond construction during the interim 1960-1980 is expected to approximate 320 acres. This acreage could satisfy about 22,000 angler-days use, and reduce fishing intensity on public waters. Small fishing impoundments are expected to add an additional 40 acres of water which could support approximately 1400 angler-days use.

The Ionia Recreation Area has been dedicated and is expected to contain two lakes, Sites 238 and 239. A general recreation lake of approximately 220 acres could be provided at Site 239, and a coldwater lake of 50 acres could be managed for trout at Site 238. The Department of Natural Resources' Fishery Division is considering a fishing lake at Site 25. This lake, on Duck Creek, would be managed as a warm-water fishery, but it might have additional potential by supplying a sustained fall flow for anadromous fish runs. The Wonadoga Creek Site has been identified as worthy of study as to possible inclusion in the State Lakes Program. While outside of the Basin's hydrographic boundary, it lies within the Basin study area.

Sites 42 on Prairie Creek and 47A on Fish Creek have excellent possibilities for high quality fisheries of considerable magnitude. Hunting potential, particularly for upland game species, is also above average at these sites. The Muir Site, Number 46, has extremely high potential for waterfowl development. This site has been placed toward the lower end of this select reservoir list. However, it could be elevated considerably if reservoir operations were regulated to optimize its waterfowl potential. The Muir Site would provide a logical refuge and adjacent hunting area for waterfowl traveling from the Shiawassee Flats National Wildlife Refuge area on down the Mississippi Flyway.

The Grand, Flat, Thornapple, and Coldwater Rivers are expected to have a major impact on anadromous fish populations in future years. The magnitude of use in these rivers has not been determined at this

time, but the opportunity they are expected to provide should satisfy many West Central Belt Subarea anglers.

f. Lansing Subarea.

(1) Projected Plans. The acreage and use estimates provided by projected fish and wildlife developments in the Lansing Subarea for the interim 1965-1980 are:

Hunting	Acres	Net Days Use
Addition to Existing Game Areas	630	650
New Game Areas	2,400	2,500
Scarce (Waterfowl) Habitat	370	230
State Parks or Recreation Areas	2,100	2,200
Secondary Waterfowl Habitat	440	270
TOTAL	5,940	5,850
Fishing		
Farm Ponds	400	28,000
Small Fishing Impoundments	42	1,500
TOTAL	442	29,500

(2) Reservoir Sites. The following potential sites were selected from among approximately fifty sites within the Lansing Subarea.

			Summer Pool		Net Days Use (Preliminary Estimate)	
Site Name & No.	Stream	Dam Site	Acres	Elev.	Hunting	Fishing
Portland (51)	Looking-glass	T6R5, Sec. 34	1,200	749	3,700	31,400
Doan Creek (59)	Doan	T3R2, Sec. 17	2,710	900	5,300	46,800
Sleepy Hollow (110)	Little Maple	T7R1, Sec. 34	550	790	2,200	14,300
Hayworth Creek (67)	Hayworth	T8R3, Sec. 18	250	690	4,200	16,800
Elsie (49)	Maple	T8R1, Sec. 11	500	705	1,460	13,900

Site Name & No.	Stream	Dam Site	Summer Pool Acres	Summer Pool Elev.	Net Days Use (Preliminary Estimate) Hunting	Net Days Use (Preliminary Estimate) Fishing
Columbia Creek (144)	Columbia	T2R3, Sec. 7	200	885	650	10,800
Okemos (57)	Red Cedar	T4R1, Sec. 27	970	860	2,300	21,000
No Name (180)	No Name	T3R5, Sec. 2	750	880	2,200	20,700
Lacey Creek (179)	Lacey	T2R6, Sec. 24	1,050	895	3,000	25,200
Hobart Creek (142)	Hobart	T1R3, Sec. 10	120	895	330	6,000
Bad Creek (162)	Bad	T7R3, Sec. 34	425	740	1,240	13,300

(3) Discussion. Net fishing demands are expected to amount to 192,500 angler-days use by 1980, 306,500 by 2000, and 438,200 by 2020, over that which can be met by opportunity existing in the Lansing Subarea in 1960 (Table II-25). Net hunting demand, when compared to 1960 opportunity, will be deficient by 145,000 hunter-days use in 2000 and 327,900 days use by 2020 (Table II-26).

The Maple River, Dansville, and Rose Lake public hunting areas now exist in the Lansing Subarea. Approximately 630 acres of additional land will be acquired for these areas prior to 1980. The goal acreage now needed to fully "block-out" subarea public hunting sites is 8,700 acres (Table IV-17). The Michigan Department of Natural Resources will judge where additional acres would be of greatest value to Lansing Subarea hunters.

If traditional acquisition patterns are adhered to, approximately 2,400 acres of game area lands will be purchased at new sites in the Lansing Subarea prior to 1980. Game areas could be developed near a number of the proposed reservoir sites.

Projected purchases of scarce waterfowl habitat are expected to total 370 acres in the Lansing Subarea. If purchase areas are not available, water control structures could be developed to provide needed wetland habitat. This type of small impoundment might be constructed in the Clinton County portion of the Maple River State Game Area or at other subarea sites having suitable habitat and topography. Water control

structures are scheduled for construction in the Gratiot County portion of the Maple River Area (Table IV-18). There is also the possibility of developing the Muir Site on the Lower Maple River primarily for waterfowl.

Secondary waterfowl habitat will be developed at farm ponds and small fishing impoundments. Although these waters usually do not attract large flights of waterfowl, they are expected to provide approximately 300 annual waterfowl hunter-days use by 1980.

Sleepy Hollow State Park is planned to contain nearly 2,100 acres of land, in addition to a 550-acre reservoir (Site 110). It is assumed that fall hunting will be permitted on these lands, at least until the year 1980. If this assumption is correct, Sleepy Hollow State Park will provide an estimated 2,200 hunter-days use per year.

There is interest in providing flood control and low-flow augmentation relief for the cities of Lansing and East Lansing. The flow augmentation method of reducing pollution problems during low stream flows is not meant to be a substitute for abatement of pollution at its source, but is justifiable only as a device for meeting residual stream quality needs after adequate waste treatment standards have been met.

The Basin Plan of Development calls for construction of a three-pool reservoir complex (Site 59-Doan, Site 58-Williamston, and Site 57C-Okemos) to yield recreation, water supply, flood control, water quality control, and fish and wildlife benefits. The upper pool (Site 59-Doan) would be managed to maintain a constant high level for recreation and fish and wildlife; and the other two pools would be fluctuating pools designed to serve other needs.

Sites 57 and 59 appear to offer the greatest potential for fish and wildlife benefits upstream from Lansing. Site 57, at Okemos on the Red Cedar River, and Site 59, on Doan Creek, lie in the Red Cedar drainage area, which is located south and east of Lansing. Zorb, in his analysis of five Red Cedar drainage sites, stated that the Okemos site "*is probably the best site of the five for recreational purposes*" and the Doan Creek site "*is probably the most realistic in view of land acquisition problems.*"

If the sites were designed to maximize fish and wildlife benefits, the maximum depth at the dam of Site 57 (Okemos) would be 29 feet with the normal summer (conservation) pool depth at the dam approximately 19 feet. Water depths at the Site 59 dam would be 30 feet with a nonfluctuating pool. The estimated summer pool acreages would be 760 acres at Site 57 and 2,600 acres at Site 59. Fishery benefits could reach 21,000 annual angler-days use at Site 57 and 47,000 days use at Site 59, if the reservoir and tailwater fisheries were developed to full potential at each site. Waterfowl and upland game benefits, using game and park lands, would approximate 2,300 days use at Site 57 and 5,300 days use at Site 59, if each site were fully developed.

Site 51, located east of Portland on the Lookingglass River, also would provide necessary opportunity to hunters and fishermen using Lansing Subarea resources. The Portland Reservoir would have a summer pool depth averaging about 30 feet. Surface acreage at this site would be approximately 1,200 acres. With full development of the site's fish and wildlife potential, preliminary utilization estimates would be 31,000 annual angler-days and 3,700 annual hunter-days.

Subarea farm pond construction is expected to total 400 acres prior to 1980 if present construction rates are maintained. This acreage could provide 28,000 annual days use for fishermen.

There are several fishing and park lake developments proposed in the Lansing Subarea for the interim 1965 to 1980. The Sleepy Hollow State Park has been dedicated, and plans call for a 550-acre lake (Site 110) formed by a 27-foot dam on the Little Maple River. The Conservation Department's Fishery Division has proposed a 120-acre lake, impounded by a 25-foot dam on Hobart Creek (Site 142). These two developments could annually provide about 25,000 angler-days use.

The remaining six sites are also worthy of consideration for fishing and park lake or multi-purpose development. Site numbers 144, 180, 179, 67, 162 and 49 have been analyzed at those elevations where fishery potentials would be maximized and induced damages to agriculture would be minimized.

The anadromous fish development program will have an effect on satisfying near-future (1980) angler needs in the Lansing Subarea, but to what degree is yet undetermined. The Grand and Lookingglass Rivers are expected to be utilized by anadromous fish populations in this Subarea prior to 1980.

g. Northeast Fringe Subarea Plan.

(1) Project Plan. The projected fish and wildlife developments in the Northeast Fringe Subarea, for the interim 1965-1980, are listed below. The acreage and preliminary use estimates that could be provided by these developments are:

Hunting	Acres	Net Days Use
Additional to Existing Game Areas	660	680
New Game Areas	2,500	2,600
Scarce (Waterfowl) Habitat	260	160
State Parks and Recreation Areas	1,700	1,700
Secondary Waterfowl Habitat	180	110
TOTAL	5,300	5,250
Fishing		
Farm Ponds	170	11,900
Small Fishing Impoundments	14	490
TOTAL	184	12,390

(2) Reservoir Sites. The following site was the only potential reservoir in the Basin portion of the Northeast Fringe Subarea that appeared to have high fish and wildlife values. Potential sites in Shiawassee and Gratiot Counties, that were outside of the Grand River Basin's hydrologic boundary, are not identified.

			Summer Pool		Net Days Use (Preliminary Estimate)	
Site Name & (No.)	Stream	Dam Site	Acres	Elev.	Hunting	Fishing
Bear Creek (109)	Bear	T7R1, Sec. 26	235	760	2,600	8,700

(3) Discussion. Although the Northeast Fringe Subarea has estimated net hunting and fishing demands that are not as great as other subareas, planning should be carefully considered to take advantage of the available terrain and habitat. Net fishing demands are expected to require additional fishing habitat over that available in 1960 (Table II-25) to sustain an additional 21,000 angler-days use by 1980, 52,700 by 2000, and 88,500 days use by 2020. The hunting opportunity available in this Subarea in 1960 will have to be increased to sustain an additional 52,800 hunter days in 2000 and 118,300 days use by 2020 to satisfy net hunter demands.

The projected acquisition for existing public hunting areas is 660 acres. This could be added to the established Rose Lake, Maple River, and/or Gratiot-Saginaw areas. The goal acreage for these three areas is 15,200 acres. Selection of where purchases should be made will depend on the State's management plans for each area, the availability of goal acres at particular areas, and the per-acre cost.

If Bear Creek (Site 109) should be constructed as a fishing lake, the 2,500 acres projected to be acquired for new game areas could be developed at this site. If plans should call for Bear Creek to be developed as a park lake, the 1,700 acres projected to be acquired for parks or recreation areas could be provided with this project. The 2,500 acres allocated to new game areas might be of greater value, with less operation and maintenance costs, if they were added to established areas which require expansion.

Projected purchases of scarce waterfowl habitat are expected to total 260 acres in the Northeast Fringe Subarea. Selection of a potential area is directed by its relation to existing waterfowl habitat and its availability for purchase. Scarce waterfowl habitat may also be provided by water control structures regulated specifically for wetland management. Such structures are programmed for construction in the northeastern portion of the Maple River State Game Area. Waterfowl habitat, on a less intensively managed scale, will be provided by fishing developments (farm ponds, fishing and park impoundments).

Preliminary hunting use estimates on the projects discussed above would approach approximately 5,300 hunter days, if all sites were fully developed.

Farm ponds will provide a great amount of angler opportunity if present construction rates are maintained through 1980. We estimate that nearly 12,000 annual angler-days use could be provided by 170 acres of this type of habitat within the Northeast Fringe Subarea.

One fishing or park lake development is proposed in the Northeast Fringe Subarea for the interim 1965 to 1980. An impoundment could be formed at Site Number 109 by placing a 30-foot dam on Bear Creek in Section 26, Township 7N, Range 1E. This dam would provide a 235-acre lake if the water surface were at elevation 760 feet. The impoundment and tailwater fishery, if developed fully, would provide an estimated 8,700 angler-days use annually.

h. Jackson Subarea Plan.

(1) Projected Plans. The acreage and use estimates provided by projected fish and wildlife development in the Jackson Subarea for the interim 1965-1968 are:

Hunting	Acres	Net Days Use
Addition to Existing Game Areas	950	980
New Game Areas	3,600	3,700
Scarce (Waterfowl) Habitat	200	120
State Parks or Recreation Areas	2,400	2,500
Secondary Waterfowl Habitat	220	140
TOTAL	7,370	7,440
Fishing		
Farm Ponds	100	7,000
Small Fishing Impoundments	11	380
Fishing and Park Lakes	110	3,900
TOTAL	221	11,280

(2) Reservoir Sites. The following reservoir sites were selected from nine Corps of Engineers and ten Soil Conservation Service impoundments located in the Jackson Subarea as having the greatest potential for fulfilling future hunting and fishing demands:

			Summer Pool		Net Days Use (Preliminary Estimate)	
Site Name & No.	Stream	Dam Site	Acres	Elev.	Hunting	Fishing
Sandstone Creek (62)	Sandstone	T1R3, Sec. 28	5,900	950	16,100	72,600
Smithville (73)	Grand	T1R3, Sec. 2	2,290	890	6,700	38,800
Liberty (10)	Grand	T4R1, Sec. 27	510	1,020	1,500	16,500
Portage River (171)	Portage	T1R2, Sec. 21	2,200	920	10,800	8,800
Spring Brook #1 (60)	Spring	T1R3, Sec. 3	2,220	930	7,800	28,900

(3) Discussion. By 1980, unfulfilled demand for fishing in the Jackson Subarea is estimated to require additional habitat to sustain 148,600 angler-days use (Table II-25). Projections of these demands indicate that a deficit of 315,700 angler-days will exist by 2000 and 497,200 angler-days by 2020. Net hunting demand is estimated to have a hunter-day use deficit of 58,700 by 2000 and 126,400 by 2020, over that being satisfied in 1960.

The Waterloo Recreation Area and Sharonville State Game Area presently provide public hunting opportunity for Jackson Subarea users. Approximately 950 acres will be added to these areas prior to 1980. The goal acreage needed to fully "block-out" the Sharonville Area is 3,300 acres (Table IV-14).

Past acquisition patterns indicate that approximately 3,600 acres of public hunting lands will be acquired at new sites in the Jackson Subarea prior to 1980. Game Areas of this magnitude could be developed in conjunction with various State or Federal Reservoir option sites.

Projected purchases of scarce waterfowl habitat may total about 200 acres in the Jackson Subarea. Small water control structures, built specifically to impound waters to benefit wildlife and waterfowl, are

scheduled at the Waterloo Recreation Area (Table IV-18). Waterfowl habitat in this area is excellent and should be managed to its full potential. Potential reservoir sites 8 and 63 would flood a large portion of the Waterloo Recreation Area, causing irreparable losses of fish and wildlife habitat, unique ecological areas, outdoor recreation developments, and the attendant enjoyment of these resources. However, Site 171 on the Portage River has been identified by the Michigan Department of Conservation as having substantial waterfowl potential. Site 60, on Spring Brook, would also have high waterfowl potential.

It is estimated, on the basis of past trends, that approximately 2,400 acres will be added to park and recreation areas within the Jackson Subarea. An expansion of the Waterloo Recreation Area could easily constitute this addition, and would be a good conservation investment for future years.

The Sandstone Creek Site (Site No. 62) was selected as having the best potential for fish and wildlife development. This site is located south of Tompkins Center and would inundate areas within four miles of the western edge of Jackson. It would impound about 5,500 surface acres of water during the summer and would have an average depth exceeding 15 feet. Preliminary estimates of use amount to 72,600 annual angler-days, predicated upon proper development and management of the reservoir and tailwater fisheries. Waterfowl and upland game preliminary benefits could total about 16,100 hunter-days use each year if a State game area and park lands were developed.

Subarea farm ponds are expected to provide 100 acres of fish and wildlife habitat if present construction rates are maintained. This acreage could provide 7,000 annual angler-days use and also reduce fishing intensity on public fishing waters.

9. <u>WATER QUALITY</u>

a. <u>Pollution in the Grand River</u>. The waters of the Grand River are degraded in quality, particularly below Jackson and Lansing and at the mouth near Grand Haven. This degradation in quality is evidenced by low dissolved oxygen levels and other biological, chemical, microbiological, and physical parameters analyzed by both Federal and State pollution control agencies.

Pollution of the waters of the Grand River is further evidenced by the impairment of water uses. Partial body contact recreation is hazardous due to high coliform bacteria and fecal streptococcus bacterial densities below Jackson, Lansing, Grand Rapids, and Grand Haven. The fishery of certain sectors of the Grand River is harmed by low dissolved oxygen levels and high stream temperatures. The State of Michigan now requires continuous chlorination at all waste plants.

b. Sources of Pollution. Municipal waste treatment plants in the Grand River basin served a 1962 population of 540,000. Their combined effluent discharged 17,000 pounds of 5-day biochemical oxygen demand daily into the Grand River and tributaries, equivalent in oxygen-consuming power to the untreated wastes of over 100,000 persons. Other municipal waste sources include the overflows from combined sewer systems.

Industrial wastes discharging directly into the waters of the Grand River basin put an additional 15,000 pounds of BOD_5 into the streams daily. These wastes are equivalent in oxygen-consuming power to the untreated wastes of 126,000 persons.

In addition to the organic waste load discharged from industries and municipalities, thermal discharges also have a significant bearing on water quality. For example, cooling water discharges from steam electric generating stations at Lansing may produce adverse local effects.

c. Future Conditons. Growth projections indicate that the 1960 Grand River basin population of 949,000 may increase more than two-fold by 2020. Industrial activity is expected to double by 1980 and to continue to expand in the decades that follow. Water demands and waste flows will increase at a more moderate pace due to increased water reuse and other efficiencies. These and other related factors indicate that the waste load received by all municipal sewerage systems in the Basin will increase to about 2,500,000 Population Equivalent (PE) by 2020. By comparison, the present estimated waste load received by all municipal sewerage systems of the Grand River basin is approximately 540,000 PE.

d. Needed Water Quality Improvements. A number of pollution control measures are presently needed in the Grand River basin. These measures, partially shown in Table III-7, include secondary waste treatment for all major municipal waste sources and equivalent treatment for all significant industrial waste sources.

In addition, the recommendations of the Four-State Federal Enforcement Conference on the pollution of Lake Michigan and its tributaries require that communities provide at least 80 percent phosphorus removal on a statewide basis.

At some locations for foregoing measures alone will not be sufficient to achieve satisfactory water quality control. The study has identified two principal locations, the Jackson Area and the Lansing Area, where additional measures are required. A study of alternative measures reduces to the following: advanced waste treatment (beyond the basic degree specified above); augmentation of low flows in the stream receiving the treated wastewater effluents; piping of effluents to a more favorable location for discharge; or combinations of these.

Estimates have been made of the streamflows required to supplement basic wastewater treatment in maintaining established water quality standards, in the reaches of the Grand River at and immediately downstream from the cities of Jackson and Lansing. These estimated flows, for projected conditions of the years 1980 and 2020, are given in Table IV-3. Section III of this Appendix presents a multiple-purpose reservoir plan to provide part of this flow.

At Jackson, which is located near the headwaters of the river system, the required flows exceed the maximum physical supply of water obtainable from the river. Therefore, a form of advanced waste treatment will be required, and the city of Jackson is now taking steps to provide it. If a multiple-purpose reservoir were to be constructed in the Jackson area, allocation of storage space for low-flow augmentation would be a valuable supplement to advanced waste treatment. Importation of water to the Jackson area is a possibility. However, unless water imported

for low-flow augmentation is part of a total quantity brought in for several purposes, the costs of transporting water from one of the Great Lakes to Jackson for this purpose alone would be greater than the cost of providing a degree of treatment high enough to eliminate any need for supplemental streamflows.

At Lansing, where the Grand River is much larger than it is above Jackson, there is a more favorable opportunity for seeking least cost combinations of wastewater treatment and low-flow augmentation.

A summary of alternatives for water quality control, and associated costs adjusted to a common time base for comparison, is given in Table IV-7.

The benefits of achieving and maintaining high quality water in the Grand River basin will be widespread and far-reaching, even though not all of these benefits are susceptible of measurement in monetary values. Moreover, it is presumed that the procedures, including public hearings, through which Michigan's water quality standards were established, justify the premise that the people in the Basin consider achievement of these quality standards to be justified and worth what it will cost. On that premise, benefits of storage for water quality control were considered to be equivalent to the cost of the least costly alternative. The average annual least costly alternative at Jackson is estimated to be $330,000 as shown in Table IV-18. The average annual least costly alternative at Lansing is estimated to be $430,000 as shown in Table IV-19

e. Streamflow Augmentation Requirements. After studying the location of principal municipal and industrial waste discharges into the Grand River and its tributaries and also the quantitative and qualitative characteristics of the receiving waters, two reaches of the main stem of the Grand River below Jackson and Lansing indicated potential benefits from flow augmentation and were selected for waste assimilation studies.

Waste assimilation studies were conducted to determine the total streamflow required to meet a range of water quality goals in the Grand River below Jackson and Lansing. During 1964 intensive stream investigations were conducted on these reaches during May, July and October.

A mathematical model reproduced the stream conditions observed during these intensive sampling periods. Using projected flow and quality data for the waste inputs within the study reaches of the stream, the model was used to compute the total streamflows required for flow regulation for water quality control. It has been assumed that a 90 percent BOD_5 removal will be provided for both municipal and industrial waste discharges.

The State of Michigan has set a minimum standard of 4.0 mg/l of dissolved oxygen below both Lansing and Jackson. The maintenance of this standard for dissolved oxygen in conjunction with the other water quality standards listed in Section III, will assure the absence of nuisance odor conditions; permit recreational use involving partial body contact; support pollution-tolerant fish such as carp and other aquatic life; and, in general, provide for the aesthetic enjoyment of clean surface waters. Streamflow requirements to maintain the required dissolved oxygen level are shown by month in Table IV-16.

The estimated ranges of total streamflow required to maintain a dissolved-oxygen concentration of 4 milligrams per liter below Jackson are 53 to 510 cubic feet per second in 1980 and 103 to 860 cubic feet per second in 2020. Below Lansing the streamflows required to maintain a dissolved oxygen level of 4 milligrams per liter are 55 to 480 cubic feet per second in 1980 and 160 to 1,760 cubic feet per second in 2020. Ranges in streamflow requirements are primarily due to the wide variation in stream temperatures over the year. Streamflow requirements satisfy both the carbonaceous and nitrogenous cycles.

The ability of existing streamflows to meet the above demands can be assessed by comparing the estimated maximum flows in 1980 and 2020 with the 7-day, once-in-10-year low flows as shown in Table IV-17. The comparison indicates that existing low flows will not be adequate to assimilate the treated waste discharges at Jackson and Lansing in 1980 and 2020. Thus, some combinations of streamflow regulation and advanced waste treatment will be required to achieve the water quality goal of 4 milligrams of dissolved oxygen per liter below Jackson and below Lansing. The Grand River and tributaries in the Grand Rapids Area were also sampled and studied. Grand Rapids is now pumping Lake Michigan water for domestic and industrial uses.

TABLE IV-16 Average Monthly Streamflow Necessary to Maintain Stated Minimum Dissolved Oxygen Levels in the Grand River below Jackson and below Lansing* (goal = 4 milligrams of dissolved oxygen per liter)

	Below Jackson (cubic feet per second)			Below Lansing (cubic feet per second)			
Year	1966	1980	2020	1966	1980	2020	
Month							Temp. C°
April	57	76	155	53	85	250	6
May	126	169	317	114	185	520	14
June	195	274	480	172	290	780	18
July	250	362	630	218	360	1020	20
August	345	510	860	290	480	1760	22
September	195	274	480	172	290	780	18
October	157	212	385	140	230	630	16
November	91	123	238	85	110	390	11
December	57	76	155	53	85	250	6
January	42	53	103	25	55	160	0
February	45	58	112	30	60	180	1
March	45	58	112	30	60	180	1

*Note Streamflows are exclusive of municipal, industrial and institutional waste discharges.

TABLE IV-17 GRAND RIVER FLOW DATA

Location	Drainage Area Above (Sq. Mi.)	Station Years of Record	Average Dis-charge (cfs)	Instantaneous Flows From Station Years of Record: Minimum Flow (cfs)	Instantaneous Flows From Station Years of Record: Maximum Flow (cfs)	Years of Record Used to Compute Low Flow	7 Day Avg. 1 in 10 Years (cfs)
Grand River at Jackson, Michigan	174	29	113	9.2*	1,070	1935-64	20
Grand River at Eaton Rapids, Michigan	661	14	407	14.0	3,360	1950-64	73
Cedar River at East Lansing, Michigan	355	34	197	3.0	5,920	-	-
Grand River at Lansing, Michigan	1,230	35	803	2.8*	24,500	1901-06, 1935-64	75
Lookingglass River at Eagle, Michigan	281	20	160	11	2,860	-	-
Maple River at Maple Rapids, Michigan	434	20	227	4.6	6,500	-	-
Grand River at Ionia, Michigan	2,840	13	1,576	105*	21,500	1951-64	175
Flat River at Smyrna, Michigan	528	14	385	7.4	2,500	-	-
Thornapple River at Caledonia, Michigan	773	20	482	-	6,290	-	-
Rogue River at Rockford, Michigan	234	12	202	30	2,640	-	-
Grand River at Grand Rapids, Michigan	4,900	38	3,370	381	54,000	-	-

*Regulation by upstream control structures.

f. Water Quality at Jackson. One method of meeting water quality standards in the Grand River below Jackson (assuming that secondary waste treatment will be universal in the Basin) would be to guarantee a minimum flow of 187 cubic feet per second by 1980 and 336 cubic feet per second by 2020.

An alternative method is incremental advanced waste treatment to yield a chemically and biologically stable effluent. Since only limited storage is available above Jackson, incremental advanced waste treatment is the more feasible alternative.

The method of treatment considered here for both Jackson and Lansing consists of chemical coagulation and sedimentation using 300 mg/l of hydrated lime and 50 mg/l of ferrous sulfate plus filtration through sand at 4 gallons per minute per square foot plus aeration of the final effluent and pH adjustment before final discharge. This treatment is in addition to conventional secondary treatment.

This degree of treatment should provide an extremely high quality effluent and would be utilized during periods of low streamflow when needed to maintain the required 4 mg/l of dissolved oxygen in the stream.

The alternative of importing water from one of the Great Lakes for augmentation was also considered. In this case a pipeline to Lake Erie capable of augmenting flows in the Grand River below Jackson was evaluated.

g. Water Quality at Lansing. One method of meeting water quality standards in the Grand River below Lansing (assuming that secondary waste treatment will be universal in the Basin) would be to guarantee a minimum flow of 191 cubic feet per second by 1980 and 575 cubic feet per second by 2020.

As in the case of Jackson, incremental advanced waste treatment was evaluated as an alternative at Lansing. The incremental unit series of treatment processes considered as an alternative was the same as at Jackson.

h. Summary of Alternative Costs. The annual costs of each of the alternative methods of meeting the water quality problems of the Jackson and Lansing areas are presented in Tables IV-18 and IV-19 respectively.

i. Benefits. Implementation of the recommendations contained in this report combined with a judicious selection from the alternatives presented will result in substantial improvement in the quality of the waters of the Grand River basin.

By their very nature benefits from water quality are diffuse and accrue to all of the citizens within the Basin and are, therefore, difficult to quantify. However, the value of these benefits was implicitly considered in the public hearings which preceded the establishment of intrastate water quality standards by the Michigan Water Resources Commission.

It is possible, however, to cite briefly some of the beneficiaries of improved water quality in the Grand River basin. Owners of property adjacent to or near presently polluted waters will derive increased aesthetic enjoyment and enhanced property values from the elimination of the unsightly conditions whcih result from water pollution. These include nuisance algal blooms stimulated by over-fertilization of the aquatic environment.

Michigan residents and visitors from out-of-state who use the area's streams and lakes for swimming, water skiing, boating and other water-oriented recreation will be protected against infectious diseases which can be spread by polluted water. The sport fisherman will find additional fishing areas and improved fishing as a benefit of enhanced water quality. As a return on its investment in clean water, industry will share in the benefits from better quality water for all of its needs.

In addition to these immediate and direct benefits the contribution of a cleaner Grand River to the preservation and protection of the quality of the waters of Lake Michigan is an important benefit and vital to the National welfare.

Table IV-18 Summary of Water Quality Alternatives at Lansing
(All costs in 1967 dollars)

Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O & M Cost	Total Annual Cost (Adjusted to 1970)
Advanced Waste Treatment	Present 1995	$ 1,600,000 2,200,000	$ 2,300,000 (4-5/8%)	$ 120,000 (50 yrs. at 4-5/8%)	$ 210,000	$ 330,000
Storage Reservoir	Insufficient Streamflow to Meet Total Requirement					
Pipeline to Lake Erie	Present	36,000,000	36,000,000 (4-5/8%)	1,800,000 (50 yrs. at 4-5/8%)	3,900,000	5,700,000

Table IV-19 Summary of Water Quality Alternatives at Lansing
(All costs in 1967 dollars)

Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate	Annual Capital Cost (Assumed Life at Interest Rate	Annual O & M Cost	Total Annual Cost (Adjusted to 1970)
Storage Reservoir (Williamston 46,000 acre-feet)	Present	$10,000,000	$10,000,000 (4-5/8%)	$520,000 (50 yrs. at 4-5/8%)	$ 46,000	$570,000
Storage Reservoirs (Millet, Mud Creek and Okemos (74,000 acre-feet)	1980	16,200,000	10,300,000 (4-5/8%)	530,000 (50 yrs. at 4-5/8%)	74,000	600,000
Storage Reservoir (Onondaga 221,000 acre-feet)	2000	25,000,000	6,400,000 (4-5/8%)	330,000 (50 yrs. at 4-5/8%)	190,000	520,000
Advanced Waste Treatment	Present 1995	3,400,000 5,600,000	5,200,000 (4-5/8%)	270,000 (50 yrs. at 4-5/8%)	160,000	430,000

SECTION V - PLAN B

1. INTRODUCTION

a. Results of public hearings and public reaction. Section V and the alternative plan (Plan B) contained herein are a result of the public reaction to the original plan (Plan A). Public expression was received both at hearings held in 1970 and through subsequent correspondence.

Prior to the public hearings, a draft of the first three sections of Appendix Q (then titled Basin Plan of Development) had been released to the public. The draft report identified water resources development needs in the Basin and proposed for public consideration an explicit plan for development of the resources to meet the needs.

Needs were identified for recreation, fish and wildlife habitat enhancement, flood control, water quality enhancement, water supply, irrigation, drainage, land treatment, and commercial and recreational navigation. The river was identified as a largely neglected environmental aesthetic resource, and the implementation of an extensive system of "valley preserves" was visualized as a means to preserve and protect the river and adjacent lands for the enjoyment and utilization of future generations.

The purposes to be served by the plan included maintenance and improvement of water quality, provision of adequate water supplies, development of water and related land resources to provide increased opportunities for outdoor recreation, improvement of fish and wildlife habitat, increased efficiencies in agriculture through land and water management, reduction in flood damages, construction of improved channels for recreational and commercial navigation, and improvement of the river for aesthetic as well as utilitarian purposes.

Plan A included two multiple-purpose reservoir complexes of three pools each, on the Red Cedar River and the Upper Grand River, both upstream from Lansing; fifteen other multiple-purpose impoundments, most of which were small impoundments to serve recreation and fish and wildlife needs, forty-two watershed development programs (fourteen of them scheduled for early action, and twenty-eight recommended for future development), and accelerated land treatment for 481,200 acres of crop, pasture, and forest land; improvements for

both commercial and recreational navigation; local flood protection; preservation of streams and related land through the establishment of valley preserves; and other programs to serve the needs of the people of the Basin. This plan was predicated on the assumption that waste treatment facilities would be adequately constructed to meet the water quality standards adopted by the State of Michigan.

The public hearings were held on 7, 8, and 9 April 1970 at Grandville, Lansing, and Jackson. One afternoon and one evening meeting was held in each city.

Testimony on the plan and elements thereof was varied, but the elements of opposition were, in general, more vocal than elements of support. In particular, much opposition to the plan was voiced by persons who own property in identified potential reservoir sites.

The rural residents of townships where recreation resérvoirs were proposed were, in general, fearful of the influx of urban recreationists from the larger cities of the Basin. In some cases they voiced the opinion that cities should provide their own recreation opportunities for their own people, rather than subject the adjacent rural areas to disruption.

Much opposition was expressed to the reduction in local tax base which results from conversion of private property to public ownership. Many citizens have been subject to recent tax increases, and are hostile to any public improvements that might further increase their taxes, directly or indirectly, especially when the benefits of the improvements are regional rather than strictly local.

Many citizens felt that the report should contain specific recommendations for advanced waste treatment facilities. In particular, they expressed doubts about the necessity for and/or efficacy of low flow augmentation as an approach to water quality control.

There were also widespread expressions of anxiety about the ecological effects of reservoir construction. Unfortunately, the kind of detailed ecological impact study that must precede actual authorization of a project for construction is beyond the scope of a broad comprehensive planning study. Although environmental factors are taken into account in the comprehensive planning process, there inevitably remain some unanswered questions, which cannot be resolved until the initiation of detailed project planning. Although

this is to some extent true of any project, it is particularly true of reservoirs, which inevitably have substantial environmental impacts, some of them beneficial and some of them adverse. The very presence of unanswered questions, however, tends to create opposition to proposals for further investigation. This opposition was encountered in addition to the other types of opposition mentioned.

b. Recognition of public opposition. Plan A was devised by the Coordinating Committee as a long-range plan to serve the needs of the people of the Grand River basin. It was the result of years of effort by dozens of specialists in both the Federal and State governments, and it is (so far as preliminary analysis can determine) a technically sound plan that would meet the economic and recreational needs of the people as indicated.

A plan cannot be judged, however, on the basis of technical soundness alone. The fact of public opposition, regardless of the reasons for it, is in itself a factor as important as any technical consideration. A plan must possess social acceptability in order to be capable of implementation; and it is *ultimately the right and responsibility of the* citizens of the Basin to plan their own future, through governmental and other institutions which are both sensitive and responsive to public opinion.

It was in order to be sensitive and responsive that public hearings were held and public expression encouraged. There is no assurance that all segments of the public were adequately represented at the hearings, but, in any case, the viewpoints of those persons who took the time and trouble to appear at the hearings and present their point of view (or who expressed themselves in other tangible ways) must be given especial consideration, since it is impossible to adequately assess and give proper weight to the viewpoints of persons who remain silent.

It was evident, therefore, that there was sufficient public opposition to justify the formulation of an alternative plan.

c. Plan B. As a consequence of public opposition to Plan A, the Coordinating Committee felt an obligation to include in Appendix Q an alternative plan which would exclude the proposals for further investigation of identified miltiple-purpose reservoir sites.

Plan B attempts to be responsive to suggestions and priorities proposed by the public. Water quality enhancement is further identified in Plan B as the highest priority need for water resources development in the Grand River basin.

Specific proposals are included in the plan for the achievement of State water quality standards in the Basin. Plan B discusses several advanced waste treatment processes including spray irrigation as possible alternatives for meeting the long-term water quality needs in the basin; and it excludes proposals for further development of multiple-purpose reservoir sites, and discusses alternative means of satisfying needs for recreation and flood damage reduction.

2. PLAN B

a. Waste Collection, Treatment, and Disposal.

(1) Introduction. Since the preparation of Plan A, the State of Michigan has prepared a water quality management plan for the Grand River basin in response to the July 1970 requirements of the U.S. Environmental Protection Agency. The State's interim plan for the basin has subsequently been approved by the Environmental Protection Agency. The interim water quality plan like the water quality features of Plan A, acknowledges the ongoing state programs and has short range goals of providing waste treatment necessary to meet the State water quality standards. A long range program will be provided in later revisions of this plan.

Plan B adopts the State's interim plan for the basin as the primary vehicle through which State water quality standards are to be met. As stated above, Plan B also discusses several advanced waste treatment processes and land disposal (spray irrigation) as possible alternatives for meeting long-term quality problems and needs in the Grand River Basin. Plan B differs from Plan A in that it does not provide for or anticipate the use of low flow augmentation as an integral part of the water quality management program, although it does indicate where the augmentation of stream flows in the basin would be helpful.

With the exception of a detailed appendix, the State of Michigan Interim Water Quality Management Plan for the Grand River basin is reprinted here (pages V-5 thru V-128) for general information.

(2) Grand River Basin Interim Water Quality Management Plan.

(a) Objective of the Plan. This interim water quality plan has been developed to provide for a sound course of action to abate existing pollution and to provide for the maintenance of water quality standards.

It is specifically intended to consider the water quality implications of imposed municipal sewage treatment plant construction in the Grand River Basin. The major goal of this program is the maintenance of water quality standards.

(b) Basin Description.

1. Geography. With the exception of about 48 miles in the western Upper Peninsula, all the land area of Michigan drains into the Great Lakes, either directly or through tributary river systems. The Great Lakes and the lands that slope into them constitute a major portion of the St. Lawrence River drainage area, which outlets into the Atlantic Ocean.

The watershed or drainage basin of a river or stream comprises all the land that contributes to its flow. Major river basins are composed of many smaller watersheds. Because of the near proximity of the Great Lakes and the State's low relief, or elevation, Michigan's drainage basins are comparatively small and the river gradients are usually gentle.

This report covers the portion of Michigan drained by the Grand River and its tributaries. (WL-08-30). Pollution control plans for the basin are contained herein.

A drainage area of 5,570 square miles makes the Grand River basin the second largest basin in Michigan. There are six major tributaries to the Grand River. They are listed below with their respective drainage areas.

River	Drainage Area (Sq. Miles)
Flat	578
Lookingglass	290
Maple	970
Red Cedar	472
Rogue	257
Thornapple	843

Most of the basin, which includes all or parts of 18 counties, has poor natural drainage as is evidenced by numerous lakes, swamps and artificial drains.

In 1837 the newly organized State launched an extensive program of internal improvements -- canal, railroad and road building. Part of this scheme was the "Saginaw and Northern Canal," which was to link the Bad (Saginaw) and Maple (Grand) rivers providing trans-state navigation. Work started in 1838 and progressed into the next year before financial disaster overtook the State and ended canal building. However, Michigan did successfully improve navigation on the Grand River from Lyons to Grand Rapids in 1848. This allowed the establishment of regular steamer service, which was used to tow flat boats up and down the river. The Grand River below Grand Rapids was maintained for navigation for many years and was last improved (for the entire distance) in 1910. At that time a 100 foot wide, 6 foot deep channel was developed, but only limited commercial use was made after the last improvement. The lower 17 miles of the Grand is presently maintained for navigation.

2. Population, Land Use and Economy.* All or parts of four state planning regions are located within the Grand River Basin. For purposes of this report, population, land use and economy of the basin will be discussed individually within each planning region. Four counties have less than 5 percent of their land area within the Grand River Basin. These counties will not be included in the above mentioned discussion.

Jackson Region. Jackson County is the only one in this planning region with a significant portion being in the river basin. Jackson County is crossed by a major east-west expressway running between Detroit and Chicago. It also has good connections with other major cities. There is growing general manufacturing in the City of Jackson. The major recreation attraction in the region is outside the Grand River Basin.

Agriculture consists mainly of general livestock and corn production. Soils are generally productive, growing season is longer than average for the State and large urban markets are nearby.

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* William J. Kimball and Gordon Bachman, County and District Land Use Patterns in Michigan, Michigan State University Cooperative Extension Service, January, 1969.

Kalamazoo-Battle Creek Region. Of the 5 counties in this region only Barry County is partially within the Grand River Basin. No major highways cross Barry County, but access to Grand Rapids, Kalamazoo, Battle Creek and Lansing is easy.

Topography is rolling and the many lakes make the county ideal for recreation use. A large state-owned recreation area is in the county, but outside the basin. Barry County is not as well suited to agriculture as is the remainder of the region although some dairying and general livestock farming is carried on.

Grand Rapids-Muskegon Region. This planning region is large, but it is not entirely within the Grand River Basin. Ionia, Kent, Montcalm, Ottawa and Newaygo are the counties in the region which are at least partially in the basin. Grand Rapids is the region center and is experiencing a rapid expansion and concentration of population. The city is also a major airlines center in the State. A major east-west expressway crosses the region and there are several commercial shipping ports along Lake Michigan (one, Grand Haven, is in the basin).

The Lake Michigan shoreline provides the major recreation features of the region.

Agriculture in the region is devoted primarily to truck farming, dairying, fruit and poultry production.

Lansing Region. Clinton, Eaton and Ingham counties comprise the Lansing planning region. These counties are almost wholly within the Grand River Basin.

The Lansing District is rapidly expanding in population, in urban growth and in industrial and commercial growth. It is a center of State government (State Capitol), a center of education (Michigan State University), and a center of industry (Oldsmobile and other automotive plants). Lansing is also a major insurance and organizational headquarters.

A major north-south highway as well as an Interstate highway run through the district. New additions to the Interstate system have linked the district with the major east-west Interstate highway between Detroit and Chicago.

The agriculture of the district is mainly dairying and general farming due to a favorable growing season, good soils and nearby markets for whole milk.

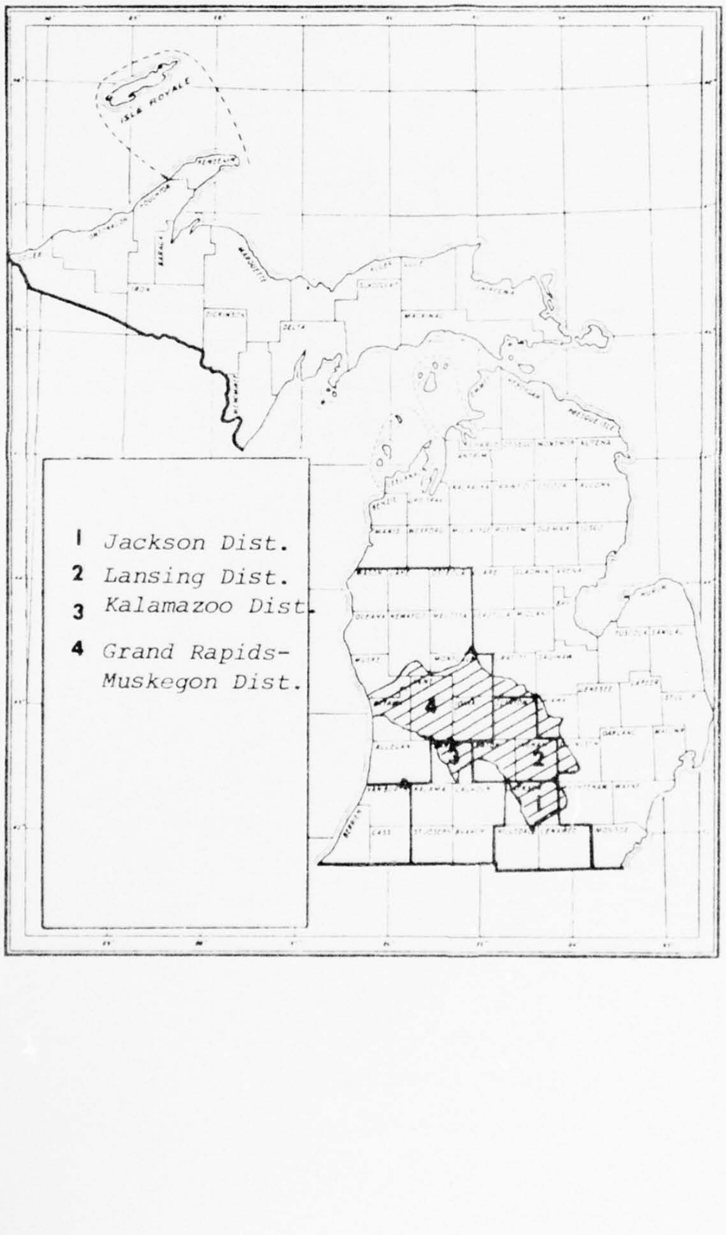


Table V-1

LAND USE IN THE GRAND RIVER BASIN 1/

	Jackson	Barry	Ionia	Kent	Montcalm	Ottawa	Clinton	Eaton	Ingham
Land Use									
Forested	85,600	84,700	58,100	117,900	125,300	79,300	41,400	51,800	54,000
% of land surface	19.1	24.1	15.8	21.6	27.6	22.0	11.3	14.2	15.1
Agriculture	209,559	178,822	249,075	222,371	229,537	165,677	258,101	248,157	217,019
% of land surface	46.8	50.8	67.8	40.8	50.7	45.9	70.6	68.4	60.8
Transportation	20,280	11,260	13,820	29,870	15,380	17,610	13,750	13,730	16,090
% of land surface	4.5	3.2	3.9	5.5	3.4	4.9	3.8	3.8	4.8
Recreation	1,882	7,958	791	5,182	798	1,672	1,046	1,320	3,517
% of land surface	.4	2.3	.2	.9	.2	.5	.3	.4	.7
Urbanized	32,070	12,150	12,680	71,460	10,850	26,470	10,960	14,970	42,650
% of land surface	7.2	3.4	3.4	13.1	2.4	7.3	3.0	4.1	12.0
Other	97,932	56,470	32,784	98,763	71,031	70,231	40,152	32,903	22,248
% of land surface	22.0	16.2	9.0	18.1	15.7	19.5	11.0	9.1	6.6
TOTAL	447,323	351,360	367,250	545,546	452,896	360,960	365,409	362,880	355,524

	Shiawassee	Gratiot	Livingston
Land Use			
Forested	39,700	46,200	82,300
% of land surface	11.5	12.8	22.7
Agriculture	244,640	269,907	169,470
% of land surface	71.0	74.7	46.7
Transportation	13,620	13,350	16,630
% of land surface	4.0	3.7	4.6
Recreation	4,110	350	5,017
% of land surface	1.2	.1	1.4
Urbanized	13,120	11,050	11,480
% of land surface	3.8	3.1	3.2
Other	29,595	20,265	77,651
% of land surface	8.5	5.6	21.4
TOTAL	344,785	361,122	362,548

* All area measurements are in acres and refer to total area of county.

1/ County and District Land Use Patterns in Michigan, Kimball, William J. and Bachman, Gordon. Cooperative Extension Service, Michigan State University, January, 1969

Table V-2

1970 GRAND RIVER BASIN POPULATION DATA 1/

County	Approximate Percent in Basin	Population in Basin 1960	Population in Basin 1970	Percent Change 1960-1970
Barry	74	23,518	28,281	20
Clinton	100	37,969	48,492	28
Eaton	71	35,029	48,423	38
Gratiot	15	5,642	5,982	6
Ingham	100	211,296	261,039	24
Ionia	100	43,132	45,848	6
Jackson	90	118,109	128,202	9
Kent	100	363,187	411,044	13
Livingston	9	3,595	5,307	48
Mecosta	2	339	447	32
Montcalm	78	28,237	31,272	11
Muskegon	6	9,314	9,445	2
Newaygo	11	2,734	3,079	13
Ottawa	51	50,021	64,949	30
Shiawassee	23	12,276	15,668	28
Washtenaw (less than)	< 1	< 1,000	< 1,000	
Allegan	< 1	< 1,000	< 1,000	
Calhoun	< 1	< 1,000	< 1,000	
Hillsdale	< 1	< 1,000	< 1,000	
Total*		444,398	1,107,478	17

* Excludes the counties with less than 1,000 in the basin.

1/ U. S. Department of Commerce, Bureau of the Census, 1970, Census of Population, Michigan

3. Hydrology. The natural streamflow pattern of the basin's rivers are rather firmly fixed - alternating between spring highs and late summer lows. There are, of course, variations and fluctuations - major floods and severe droughts do occur. However, the normal year-in, year-out streamflow pattern is a product of the physical condition of an individual river's drainage basin. A pattern that reflects the combined effect of climate, topography, geology and vegetative cover. Basin streamflow recoreds and recorded extremes were shown in table .

The 7 day, 10 year average flows are shown in table

Table V-3

7 Day, 10 Year Low Flows

Station	*7 Day, 10 Year Low Flow in CFS*
Grand at Jackson	*21.0*
Grand at Dimondale	*66.0*
Grand at Lansing	*72.0*
Grand at Grand Ledge	*87.0*
Grand at Portland	*105.0*
Grand at Ionia	*181.0*
Grand at Grand Rapids	*681.0*
Grand at Grandville	*811.0*
Grand at Grand Haven	*898.0*
Red Cedar at Williamston	*7.0*
Red Cedar at East Lansing	*8.0*
Looking Glass at Dewitt	*13.0*
Sycamore Creek at Mason	*2.0*
Maple at Maple Rapids	*7.0*
Maple at Muir	*19.0*
Flat at Greenville	*69.0*
Flat at Smyrna	*118.0*
Thornapple at Nashville	*13.0*
Thornapple near Hastings	*46.0*
Thornapple at Caledonia	*113.0*
Carrier Creek at Delta Township, Eaton County	*0.11*
Rogue at Rockford	*61.0*

Table V-4

STREAMFLOW RECORDS AND RECORDED EXTREMES

Stream and Station	Drainage Area Square Miles	Period of Record by Water Years	Average Discharge cfs		Momentary Maximum Discharge cfs	Minimum Daily Discharge cfs
Grand River at Jackson	174	1936 - Present	111	(31 years)	1,070	12.0
Grand River near Eaton Rapids	661	1951 - Present	396	(16 years)	3,360	21.0
Deer Creek near Dansville	16.3	1955 - Present	8.56	(12 years)	570	0.19
Sloan Creek near Williamston	9.34	1955 - Present	4.41	(12 years)	685	0.02
Red Cedar River at East Lansing	355	1903,1931 - Present	194	(36 years)	5,920	3.0
Grand River at Lansing	1,230	1902-1903, 1931 - Present	790	(37 years)	24,500	20.0
Grand River at Portland	1,385	1953 - Present	737	(14 years)	9,100	58.0
Looking Glass River near Eagle	281	1945 - Present	157	(22 years)	2,860	10.0
Maple River at Maple Rapids	434	1945 - Present	228	(22 years)	6,500	4.4
Grand River at Ionia	2,840	1951 - Present	1,570	(15 years)	21,500	115.0
Flat River at Smyrna	528	1951 - Present	388	(16 years)	3,020	70.0
Quaker Brook near Nashville	7.60	1955 - Present	5.04	(12 years)	294	0.6
Thornapple River near Hastings	385	1945 - Present	278	(22 years)	6,810	33.0
Thornapple River near Caledonia	773	1931-38, 1952 Present	485	(23 years)	6,290	64.0
Rogue River near Rockford	234	1953 - Present	205	(14 years)	2,640	49.0
Grand River at Grand Rapids	4,900	1902 - Present	3,353	(40 years)	54,000	381.0

4. Water Quality.

a. Existing Water Quality. The chemical composition of water in lakes, streams, and in the ground is basically the product of the region's environment. The measurement of quality is, in effect, a partial determination of that environment.

Within practical limits, the prime source of Michigan's fresh water - precipitation - is uniformly pure as it falls across the state. The ultimate quality is then the result of additions from the materials the waters run across and through and the natural and cultural additions after the waters have reached a lake or stream.

Drainage basin influences upon water quality are partially reflected in the appearance of the stream. Sandy soils, with their receptiveness to infiltration, tend to support clear, cool "trout waters," while the heavier, less pervious soils, with their associated overland runoff, tend to support more turbid, warm and fertile streams. However, other water quality aspects may be quite invisible and an apparently "pure" brook can be chemically and bacteriologically inferior to one whose tannin, algal or sediment content would identify it to the layman as being polluted.

Seasonal and climatic changes, land use practices, and industrial and municipal uses may be reflected in water quality.

A casual water sample is apt not to produce a true indication of surface water quality. Usually a true picture can be developed only from studies over a period of time, that include all of the conditions that may alter the three principal criteria of water quality - chemical, physical and biological composition.

Streams with fairly constant flow tend to maintain fairly uniform water quality, except as altered by man's additions. With great seasonal variations in flow, variations in water quality are usual. During periods of low streamflow the main sources are groundwaters, consequently the basic water quality is that of the groundwaters. Conditions that lead to high runoff during the spring may result in substantial land wash which can bring sediment, commercial fertilizers, and the accumulated debris of urban areas to a stream, yet, because of the large addition to flow, may not deteriorate the water quality. The

appearance of a stream during these periods of high flow is not a reliable indication of its quality.

The following discussion of municipal wastewater treatment plants is a complete listing of all existing or proposed facilities in the Grand River Basin. In each river basin discussion begins with the most upstream community and progresses down river.

1. Grand River

Jackson Area

The Grand River has its beginning a few miles south of the City of Jackson in Hillsdale County. It is still a small river when it reaches this growing industrialized center of population. The wastewater treatment plant in Jackson presently serves about 50,000 people including some residents of adjacent townships and some nearby industries. This plant has an average discharge of 10.50 MGD.

A June, 1967, agreement with the Michigan Department of Public Health called for upgrading of present treatment (to a modified activated sludge plant) and construction of a stormwater retention basin. These facilities are now under contract to be constructed.

Waste discharges from the Jackson area are limited to 1,700 pounds per day of ultimate BOD of which no more than 400 pounds per day can be 5 day BOD. These restrictions apply during the four summer months (120 days). The remainder of the year 95 percent BOD removal is required. These restrictions are based on a low flow of 20 cfs.

Because of the plan for Jackson to treat the wastes from portions of Blackman, Napoleon, Spring Arbor and Summit Townships (an additional 50,000 people), and because Leoni and the remainder of Spring Arbor Townships will construct lagoons and use spray irrigation thereby not discharging to the river, the City of Jackson has been allotted 94 percent of the total allowable BOD. The remaining 6 percent is allotted to Southern Michigan Prison. The prison is now giving serious consideration to joining the Jackson Waste Treatment System. Jackson received 1970 State and Federal grants to upgrade treatment including phosphorus removal.

Alternatives suggested include low flow augmentation. This alternative was examined by the then Federal Water Quality Administration and not found to be satisfactory. River volume needed to assimilate the increased volume of wastes from the Jackson W.W.T.P. by 1980 is likely to exceed the maximum physical supply of water obtainable from the river. An average annual flow of 187 cfs will be required by 1980, but the average annual flow for 31 years of record is 111 cfs. The Grand River Basin Study for possible dam sites identified three such sites above Jackson. If all three sites were used, flow would still not be sufficient. The study also proposed a series of dams below Jackson and transportation of waste below the dams but this was dropped because of social, economical and political unacceptability.

Other long-range alternatives are on land disposal and advanced treatment and flow augmentation by bringing water in from the Great Lakes.

Grass Lake

Presently, Grass Lake is served by individual septic tanks and seepage to the Grand River is occurring from these tanks. The village has applied for a 1970 grant and has refiled this application for 1971 to obtain funding for a lagoon system to serve a design population of 1,200.

Spring Arbor College

Spring Arbor College is served by their own lagoon system with spray irrigation which provides adequate treatment. Spring Arbor Township is considering the possibility of using this facility along with the college. Expansion of the lagoon system is being considered as part of the Jackson County Metro Area Plan.

Leslie

This community of approximately 1,800 is being served by a primary wastewater treatment plant. At this time, the treatment is adequate to meet the water quality standards of Huntoon Creek, although future population growth may may alter this situation. Water quality evaluations will monitor the need for upgraded treatment in the future. Combined sewers cause excessive flows through the plant and there is a need to separate the stormwater and sanitary sewers.

Eaton Rapids

As the river progresses through Eaton County it receives the discharge of the City of Eaton Rapids W.W.T.P. The city was given a Final Order of Determination by the Water Resources Commission which called for removal of 80 percent

of the phosphorus compounds in the effluent. Since the timetable for meeting the Final Order has not been followed by Eaton Rapids, the Commission has ordered a show cause hearing for the city.

The Eaton Rapids plant, which provides primary treatment, discharges an average of 1.1 MGD to the Grand. Industrial wastes treated include cannery, paper, pickle and stamping wastes. Design population for the plant is 4,500 and average design flow is 1.0 MGD. The plant is operating at or near capacity. Expansion of facilities will be necessary in the near future. A phosphorus removal study has been completed.

Dimondale

Private septic tanks were used for sewage disposal in Dimondale until this year. In 1967, a Final Order of Determination was issued to the village ordering them to abate pollution of the Grand River. The village received a WPC grant in 1968 and a secondary wastewater treatment system was just completed. The plant provides treatment by the activated sludge method. Effluent is discharged to gravel lined pits and is allowed to percolated into the ground. An overflow pipe is provided for discharge from the pits to the Grand River. The design population is 2,000 with average daily flows of 0.2 MGD.

Lansing Area

In the Lansing Metropolitan area there are two large W.W.T.P.'s and three smaller plants discharging to the Grand or to tributaries near their confluence with the Grand. Lansing, Delhi Township and Delta Township discharge to the Grand River while East Lansing discharges to the Red Cedar River and Mason uses Sycamore Creek. All five municipalities have either signed stipulations with the Water Resources Commission or are under order to remove at least 80 percent of the phosphorus compounds from their waste.

Lansing

Lansing's plant has a design population of 178,000 and average design flow of 34.0 MGD. The average daily discharge is 24.0 million gallons. Lansing has received grants in 1964, 1965, 1967 and 1970 for improving and expanding waste treatment facilities. Preliminary plans for phosphorus removal have been submitted to the Commission. A combined sewer system results in excessive flows during heavy rainfalls. The excess flow is bypassed to the river after receiving

primary treatment and chlorination. Fifty-five regulating structures and a four million gallon retention basin overflow during wet weather. The city has begun a project to separate some of these sewers. Industrial wastes coming to the treatment plant originate from plating plants, foundries and truck and automobile plants.

The Water Resources Commission adopted a Final Order against Lansing on June 25, 1971. The order requires upgraded treatment by the end of 1974 and stormwater control by December 31, 1976.

East Lansing

East Lansing has a secondary treatment plant which has a discharge of about 10 MGD. East Lansing's plant was designed to handle 76,000 people including Michigan State University and part of Meridian Township and an average of 8.0 MGD waste. Flows in excess of 8 MGD have been bypassed to the Red Cedar with only primary treatment. There is also a problem of stormwater overflow from combined sewers. East Lansing was offered a stipulation in April 1971 by the Water Resources Commission. The stipulation states that the City will commence work on Phase I of their plan to upgrade treatment. The Phase I plan includes prevention of solids loss and alteration of existing aeration tanks. Phase II would provide for future growth and tertiary treatment to meet effluent criteria being stipulated by the Water Resources Commission. The City has filed a grant application for 1971. A December 1974 date was agreed on for completion of treatment upgrading.

Delhi Township

Delhi Charter Township has a primary treatment facility which discharges an average of .33 MGD to the Grand River. Design flow of the plant is 1.1 MGD for an average and design population is 11,000. The plant presently serves about 8,500. Phosphorus removal is required by December 1972. Present primary treatment provides a better effluent than normally expected from a primary plant. Because of rapid growth in the township, it will be necessary to expand the plant and upgrade treatment in the near future.

Mason

The City of Mason W.W.T.P. is a secondary activated sludge plant. The plant was built in 1957-58 and now treats an average daily flow of .45 MGD.

The plant provides about 96 percent removal of suspended solids and 94 percent removal of BOD. Design flow of the plant is 1.2 MGD and design population is 6,000. This is about the population being served presently. At the time the plant was designed a large portion of the waste load was from Wyeth and Mason Dairy operations. Both of these operations have now been removed from the system. Hence flow and BOD and solids are less at the present time than was predicted in 1957.

A stormwater overflow exists but plans are proposed to eliminate this problem. Plans have also been prepared to enlarge and update the plant as well as provide phosphorus removal. Mason has applied for State and Federal aid for improvements to their treatment facility.

Delta Township

Delta Charter Township has a secondary W.W.T.P. which discharges an average of 1.5 MGD to the Grand River. Design capacities are 10,000 for population and 1.0 MGD for flow. Although treatment provides 80 plus percent BOD and suspended solids removal, a problem exists due to the fact that the discharge is only 5 miles below the Lansing discharge and the river has not fully recovered from that discharge. A flow of 4 MGD is expected by 1980 because of rapid development of the area. Because of this and the necessity for phosphorus removal, the Township plans to expand and improve treatment facilities. Construction grants were applied for and received for both enlarged and improved treatment works and an interceptor which will serve additional area. Work is underway on both projects.

Meridian Township (Ingham County)

This township has been served by the East Lansing treatment facility since 1962. Due to rapid growth it is now necessary to provide increased pumping capacity. The Township has received State and Federal grants to make force mains and pumping station improvements. Average flow through the interceptor is about .95 MGD. Design year for the interceptor is 1980 at which time it is projected to serve 30,700 people. Presently 23,000 people are served.

Because of the large volume of treated waste entering the Grand River in a comparatively short span; 10 MGD to the Red Cedar River about 1-1/2 miles about the confluence with the Grand: 36 MGD from Lansing's plant about 4 miles

below the Red Cedar confluence and 1.5 MGD from Delta Township 5 miles below the Lansing outfall; a serious problem exists particularly during low flows. Further, the fossil fueled steam electric generating plant being built south of Lansing is expected to go into operation in 1972. The first unit will consume an average of 2.3 cfs and a peak of 3.3 cfs from the Grand River. Five additional units are planned, one every four years. The removal of water occurs upstream from the above waste treatment plants. Water loss takes place through evaporation from cooling towers. At the present time both the Red Cedar from Harrison Road to the Grand and the Grand from Moores Park Dam to Grand Ledge are protected for tolerant fish. These designations are to be reviewed in January, 1974, and may be raised at that time. This will further necessitate a higher degree of treatment than is currently provided by these plants. One proposal is to send the conventionally treated waste from the three plants to a fourth polishing or finishing plant which would produce a stable effluent.

In addition to more treatment, studies have been made to determine the feacibility of low flow augmentation. It has been shown that low flows do not provide dilution sufficient to maintain 4.0 mg/l dissolved oxygen. This is assuming that BOD removal will be 90 percent for both municipal and industrial wastes. Therefore additional water is needed. The Grand River Basin Study identified seven sites on the Grand or its tributaries between Jackson and Lansing which are possible reservoir sites (see Table V-1). If reservoirs were utilized it is possible that some part of the water would be used for Lansing water supply by the year 2000. A third alternative is on land disposal in the form of spray irrigation. The major disadvantage of this method is the high cost of acquiring the large amount of land required. A fourth alternative is piping in water form the Great Lakes to augment flow. In addition, there are several ways in which the five treatment plants included could combine, none of which has been suggested to be best.

Table V-5

POSSIBLE RESERVOIR SITES
ABOVE LANSING

1 LOCATION	2 STORAGE VOLUME AVAILABLE (Acre-feet)	3 DRAINAGE AREA AT DAM (Square Miles)	4 AVERAGE STREAMFLOW AT DAM (Cubic Feet/Second)	5 AVERAGE ANNUAL STREAMFLOW (Acre-feet)	6 AVAILABLE STREAMFLOW (Acre-feet)	7 RATIO 6/2
Onondaga	221300	569	398	288000	271732	1.2
Spring Brook #2	19000	18	13	9412	9412	0.5
Millet	63700	856	594	430000	183020	2.9
Mud Creek	31600	32	22	15928	15928	0.5
Sycamore Creek	14000	102	71	51400	35472	2.5
Williamston	67200	228	160	115840	115840	1.7
Okemos	23800	306	214	154036	87736	3.7

Approximate storage available for water supply or water quality control at Lansing is given by the sum of the underlined figures plus the storage available at Jackson, namely, 364468 Acre-feet.

Grand Ledge

In 1938, Grand Ledge built a primary wastewater treatment plant with a design flow of 1.0 MGD. This plant has been improved once by a WPC grant in 1957, but it is not capable of serving the present population of 6,000 effectively.

In 1969 a Stipulation was issued to the city calling for the upgrading of the present facility to improve treatment. A 1970 WPC grant was received for the purpose of adding interceptors and pumping stations. A 1971 grant has been requested for adding phosphorus removal and secondary treatment. The modified facility will have a design flow of 2.0 MGD and a design population of 8,000. Construction is scheduled to begin by September 1, 1971 and be completed by December 1, 1972.

Mulliken

Mulliken is now being served by private septic tanks for a population of about 500. The village received a 1970 WPC grant, with the assistance of the Eaton County Board of Public Works, to build stabilization lagoons. The design population for this facility is 750. Construction began in March, 1971, and is expected to be completed in September, 1971.

Portland

The City of Portland is under a Final Order of Determination to abate pollution of the Grand River. A primary wastewater treatment plant with a design flow of 1.3 MGD is serving the 3,800 residents of the City. A 1971 grant has been applied for by the City to add secondary treatment in the form of activated sludge facilities along with floculation for phosphate removal. The design flow of the upgraded plant will be 2.2 MGD and the design population will be 5,000. This improvement will bring treatment up to an adequate level to meet water quality standards of the Grand River.

Ionia

A Stipulation was issued to the City of Ionia in 1969 to abate pollution of the Grand River. The City is presently served by a primary wastewater treatment plant which has achieved 41 percent BOD removal and 51 percent removal of suspended solids. Ionia's primary plant has a design flow of 1.2 MGD and is now serving a population of about 6,700. The city proposes to expand its existing facilities to provide the equivalent of secondary treatment.

The city received a WPC grant in 1965 and has applied for a 1971 grant. The proposed project includes addition of secondary treatment with phosphate

removal. The design flow would be 4.5 MGD to serve a design population of 15,000 by 1990. This treatment will be adequate to meet the water quality standards at this section of the Grand River with its 7-day, once in 10 year low flow of 181 cfs. Negotiations are nearing completion for the city to treat wastes from the State Hospital, Reformatory, and Training Unit presently served by primary treatment.

Easton and Ionia Townships which surround the City of Ionia have been offered Stipulations of agreement to abate pollution of the Grand River. Neither township has signed the agreement to date, their position being that they are not responsible for the pollution problem. The Water Resources Commission has referred the case to a Hearing Commissioner for the taking of testimony evidence and arguments on the facts and the law relating to the above problem.

Saranac

In 1939, the Village of Saranac built a primary wastewater treatment plant consisting of a two unit septic tank system. This facility was achieving less than 25 percent BOD removal and less than 46 percent removal of suspended solids.

In 1967, the village received a WPC grant and constructed a lagoon system. The new facility has a design population of 2,000 and a design flow of .20 MGD.

Byron Township (Kent County)

Byron Township including the Village of Byron Center provides municipal waste treatment by stabilization lagoons. About .20 MGD is handled by the facility. Discharge is on a semi-annual basis to Buck Creek, a tributary of the Grand River. Treatment is adequate at this time. A portion of the Cotterville area is served by Wyoming.

Ada Township (Kent County)

In 1966, Ada Township constructed a lagoon system to replace the use of private septic tanks. The design population is 1,200 and they are now serving over 1,000 residents.

The community has a 1971 application for a WPC grant in order to expand the lagoon system to a design population of 2,700. The community considered pumping its waste into the Grand Rapids wastewater treatment system but various reasons made this alternative unacceptable at this time.

Cannon Township (Kent County)

Cannon Township has a 1971 grant application to build an interceptor to connect with North Kent Sewage System to pump its waste to Grand Rapids to be treated. The township has a population of 2,000 and the design population of the interceptor is 8,000. This action should adequately relieve the problem of

seepage from private septic tanks into the waters of the Grand River.

Kentwood

Kentwood is presently served by private septic tanks. To improve treatment and prevent damage through seepage, this community has applied for a 1971 grant to connect to the Pinnebrook interceptor. This interceptor will transport the sewage from Kentwood to the Grand Rapids wastewater treatment plant. The present population of the village is 3,500 and the interceptor is designed to handle a population of 6,300.

Grand Rapids

The City of Grand Rapids and its Metropolitan Area constitutes the largest single wastewater treatment plant service area in the Grand River Basin. A secondary treatment facility with a design flow of 44.0 MGD serves the present population of 235,700.

Grand Rapids has received a 1970 grant for expansion of the wastewater treatment plant to a design flow of 90 MGD. This modified plant will have a design population of 350,000. The city is under a Stipulation from the Water Resources Commission and construction of the project is due to begin June 1, 1971, and be completed by December 1, 1972. Phosphate removal facilities will also be completed by that date.

This expansion by the Grand Rapids wastewater treatment plant will include wastes from several other municipalities in the immediate vicinity. Communities which have contracted directly with Grand Rapids for sewage treatment include: East Grand Rapids, Walker and Kentwood. Alpine Township and Rockford are also served at Grand Rapids through sub-contractual arrangements with Plainfield Township.

Another major influence on effluent quality from the Grand Rapids wastewater treatment plant is the effect of industrial wastes. Forty-five industries send their wastes through the Grand Rapids plant. Wastewater from paper, plating, meat packing, laundry and foundry concerns add about 17 MGD to the flow through the W.W.T.P. Some of these sources add waste with BOD contents from 100 mg/l up to 7,000 mg/l. These various types of industrial waste materials add greatly to the job of the W.W.T.P. in Grand Rapids.

The plant discharges at a point 35 miles from where the Grand River empties into Lake Michigan. It is estimated that the quality of a 60 mile segment of the Grand River is improved due to the fact that several communities

are served by the Grand Rapids W.W.T.P. rather than each community having its own discharge into the river.

Wyoming

The City of Wyoming signed a Stipulation issued to it by the Water Resources Commission. The city received a WPC grant in 1962 to upgrade its W.W.T.P. to a secondary facility with trickling filters. The design population equivalent of this plant is 85,000 and it serves a population of 31,000. BOD removal by the facility is 78 percent while 72 percent of the suspended solids are removed. Of the 6 MGD flow, 3 MGD come from domestic sources and 3 MGD come from the 28 industrial and commercial users. Heavy metals and cyanide have occasionally destroyed biological agents in the W.W.T.P.

Wyoming has applied for a 1971 grant for expansion of the present W.W.T.P. and addition of phosphate removal facilities. Design flow would be 19 MGD and design population equivalent of the modified plant would be 190,000. Actual projected population to be served is 112,000. Industries will be limited as to the amount of heavy metals or other toxic materials that they may put into the system.

Grandville

Grandville presently applies secondary (activated sludge) treatment to its wastewater. The plant serves about 10,200 people and has an average flow of 1.25 MGD. Effluent quality with the exception of phosphates is excellent. The city signed a Stipulation with the Water Resources Commission in July, 1969, agreeing to provide 80 percent phosphorus removal from their discharge. Construction was expected to begin in August, 1971. Grandville was also planning to extend their service area. Included in the expansion would be a paper industry which currently causes pollution of Roy's Creek. Grandville received a 1963 grant to assist in construction of their plant. On August 5, 1971, this project was declared economically unjustified and placed on inactive status.

Gaines Township (Village of Dutton)

This community is now served by individual septic systems. In February, 1970, the Water Resources Commission issued a Final Order of Determination to abate pollution of Plaster Creek, a tributary of the Grand River. Treatment

equivalent to secondary with phosphorus removal is required. Final plans for collection and treatment have been approved and construction will begin in May, 1971. A population of 350 will be served initially but design population is 800. This community is receiving State and Federal financial assistance.

Ottawa County - Grand Valley State College, Allendale and Georgetown Townships

At the present time the College has stabilization lagoons operated by Ottawa County. The effluent is discharged to the Grand River. Up to now the system has provided adequate treatment. The lagoons have reached capacity and because of the necessity of removing 80 percent of the phosphorus from their wastes the county has proposed to change treatment methods. Spray irrigation and mechanically aerated oxidation ponds are planned. Design population is 5,000 people. This includes expected college growth and surrounding areas as well. The county has applied for financial assistance for the project.

Ottawa County Infirmary - at Eastmanville

This institution did rely on septic tanks for waste treatment which was inadequate. The infirmary has about 65 persons including staff to serve. Ottawa County received State and Federal grants in 1970 to assist in construction of lagoons. This project has been completed and treatment is now adequate.

Coopersville

Coopersville now has secondary treatment (trickling filter) but the plant is operating at double design capacity thus not achieving maximum efficiency. An average of .33 MGD are discharged to Deer Creek. This problem coupled with the necessity of providing 80 percent phosphorus removal has prompted the planning of a new wastewater treatment plant. Coopersville received a 1970 grant to aid in construction of a lagoon system. The project will be completed by spring, 1972. Design flow for the new plant is .49 MGD and design population is 3,900. A new trailer park was opened recently with a population of 600-900 persons.

ADDENDUM TO INTERIM WATER QUALITY MANAGEMENT PLAN
FOR THE GRAND RIVER BASIN
FEBRUARY 1972

At the present time Grand Haven and Spring Lake operate separate primary sewage treatment plants. Both plants are overloaded and produce a poor quality effluent. Spring Lake signed a stipulation with the Water Resources Commission agreeing to provide phosphorus removal. A Final Order of Determination was adopted against Grand Haven requiring phosphorus removal.

Grand Haven and Spring Lake in 1969 formed a sewer authority to construct and operate a joint sewage treatment facility. The Grand Haven-Spring Lake Sewer Authority then applied for State and Federal grants to construct a plant which will provide at least 80 percent phosphorus removal and secondary treatment by the activated sludge method. The plant will have an average design flow of 5.0 MGD. This will provide capacity to 1995 for the projected populations of 5,000 for Spring Lake and 18,000 for Grand Haven. In addition, the Eagle-Ottawa Leather Company which is under order from the Water Resources Commission to abate pollution, will contribute a controlled flow of 1.0 MGD.

Although the City of Ferrysburg has no pollution problem identified by the Water Resources Commission or the Michigan Department of Public Health at this time, the City has indicated that they wish to be included in the Sewer Authority's service area. Previous negotiations between Ferrysburg and the Authority were not successful in producing a contract for service. The Authority's plant design therefore does not include capacity for Ferrysburg through 1995.

However, it is the intent of this interim basin plan that Ferrysburg be a part of the Grand Haven-Spring Lake Sewer Authority service area. Every effort should be made by the parties involved to resume negotiations and arrive at an equitable solution for providing service to communities not now members of the Authority. It should be up to the City of Ferrysburg whether they join the system when it is put into operation or at some later date unless a pollution problem is identified.

Initially, Ferrysburg would contribute very little flow since they do not yet have a sewage collection system. Flows as projected by Ferrysburg are 0.15 MGD in 1982 and 0.34 MGD in 1992. It is estimated that the regional plant would then reach capacity about 1990 with the flow from Ferrysburg.

Grand Haven Township held a referendum to determine whether or not they would participate in the regional system. The proposal to join the Authority was turned down but the Township did request to be included in the service area which has been done. Grand Haven Township has estimated that they would need capacity for 0.25 MGD by 1982 and 0.65 MGD by 1992. This would then mean expansion of the regional plant no later than 1985 with the flow from the Township and Ferrysburg.

Spring Lake Township while not wanting to participate in the Authority is included in the service area. Their capacity needs have not yet been determined.

Because of the uncertainty of which units of government would require service and when and therefore the uncertainty of required plant capacity, the Authority's engineers designed the plant so that additions in increments of 1.5 MGD capacity can be made with a minimum of difficulty. The plant site is also large enough to permit several such expansions if necessary. It should be noted that the flows projected by both Grand Haven Township and Ferrysburg could vary greatly depending on actual population increases and how rapidly collection systems would be installed.

Accompanying this addendum to the Interim Water Quality Management Plan for the Grand River Basin is a resolution from the Grand Haven-Spring Lake Sewer Authority which states they will provide service to other Jurisdictions.

Wright Township (Ottawa County)

This township which includes the Village of Marne provides waste treatment by stabilization lagoons. A semi-annual discharge is allowed from the two cell system into the Grand River. Treatment is adequate. Wright Township received an FHA grant and a State grant to aid in construction of the facilities.

Ravenna

In 1970 this community began providing sewage collection and treatment by stabilization lagoons and spray irrigation. Discharge to Crockery Creek, a tributary of the Grand River is an alternate. The system was designed to serve 1,400 people and has a design flow of .14 MGD. Ample room has been provided for expansion. The community was under a 1968 Final Order of Determination to abate pollution of Crockery Creek and with Federal and State grants, this has been accomplished.

Grant

This community has had adequate waste treatment since 1957 when secondary treatment facilities and sand filters were installed. Flow is about .08 MGD. Discharge is to a branch of Crockery Creek and then to the Grand River.

Summary

The Grand River receives in addition to the flows of 6 major tributaries, the effluent from 32 municipalities either directly or via minor tributaries. Below Jackson and Lansing water quality is not good. Use designations provide for protection of tolerant fish warm water species in these two areas. These designations will apply only until January 1974 by which time the waste disposal situations involved are to have been placed before the Water Resources Commission for critical reconsideration with a view toward the application of higher quality use designations. Elsewhere in the Grand River 5 reaches are protected for recreation - total body contact.

The major tributaries bring to the Grand River water of as good a quality or better than that in the Grand at the various confluences. Of the 32 communities now discharging to the Grand or to small tributaries, ten have adequate treatment and 18 are in the process of attaining a higher degree of treatment. This will be done before December 1972. Six more communities are now constructing new facilities and two are building interceptors and will join the Grand Rapids system. Two communities have submitted plans to build waste treatment facilities. The culmination of all of these projects will provide a tremendous boost to the water quality of the Grand River.

2. RED CEDAR RIVER

Fowlerville

The Red Cedar River receives the municipal waste of 3 communities in addition to East Lansing. Fowlerville is the uppermost community on the river. This community discharges an average of .16 MGD after lagoon treatment. Treatment is adequate. The lagoons are hydraulically overloaded and often overflow without adequate treatment.

Webberville

Webberville is the next community downstream from Fowlerville. A sewage collection system and treatment facility were completed in 1969. Treatment consists of a stabilization lagoon and discharge is about .1 MGD to the Red Cedar. The facility now serves about 900 people and is designed to serve 2,500. Design flow is .25 MGD. Webberville was given a Final Order of Determination in January 1968 to abate pollution of the Red Cedar River. The facility was financed in part by State and Federal monies. Webberville now meets water quality standards.

Williamston

Williamston is the third municipality discharging to the Red Cedar. This community discharges .25 MGD. At the present time wastes receive only primary treatment but construction began in June, 1971, to expand and upgrade treatment to include secondary treatment by activated sludge with oxidation towers. Phosphorus removal is included. A Stipulation calling for these improvements was signed with the Water Resources Commission in August of 1969.

The existing plant was constructed in 1954 after the Water Resources Commission ordered the city to abate pollution of the river. It was designed for a flow of .24 MGD. About 2,700 people are served by the system at present. Plans for the improvements call for a design flow of .50 MGD and design population of 5,000. Williamston has received State and Federal aid for this construction.

East Lansing and Mason

These communities were discussed previously in the "Lansing area."

Summary

Overall, gross water quality conditions in the Red Cedar River are fair to good. Low dissolved oxygen and high temperatures and high organic loadings exist below populated areas. The most serious industrial discharge has been brought under control and is now rated "B" by the Water Resources Commission. Accelerated plant growth occurs in nutrient enriched segments of the river.

3. LOOKINGGLASS RIVER

Perry

Perry is the uppermost community in the Lookingglass River Basin. The present population in Perry is about 1,400 and the design population for the proposed waste treatment facility is 2,000. Design flow is .16 MGD. The discharge would flow via three different drains a distance of about 12 miles before entering the Lookingglass River. Discharges from the lagoon will be allowed only during April and November. Perry received a grant in 1970 to assist in construction of a collection system and treatment facility. The project is scheduled for completion in July, 1971.

Laingsburg

This community presently has a population of about 1,050. There has been no treatment provided other than private septic tanks, most of which are connected to an existing sewerage and stormwater system. The stabilization lagoons are designed for a population of 1,500 and have a design flow of .37 MGD. Laingsburg is uder a Final Order of Determination by the Water Resources Commission to abate pollution and completion of the facility is scheduled for September 1971. The community received a 1970 grant for construction.

Bath Township - Clinton County

No treatment is provided at the present in Bath Township. However, a problem does exist because of density of population in some areas. The township has asked the Clinton County Department of Public Works to handle the project of providing treatment. A multi cell lagoon system along with collecting sewers and interceptors is planned. Application for a 1971 State and Federal grant has been made.

The Township was ordered on June 25, 1971 by the Water Resources Commission to correct raw sewage discharges to drains.

Watertown Township - Clinton County

The township has no municipal treatment facility at the present time. Application has been made for a 1971 State/Federal grant to assist in construction of a pumping station and interceptor to the DeWitt wastewater treatment plant.

DeWitt

DeWitt currently has a primary treatment plant which discharges about .06 MGD to the Lookingglass River. This is about one-fourth design flow. The

community was ordered in 1962 to provide the treatment. It is now necessary for the city to provide secondary treatment and phosphorus removal. Primary treatment is removing only about 23 percent of incoming BOD and 51 percent of suspended solids. Approximately 65 percent of the city's population is served by the facility. A maximum of 300 pounds of 5 day BOD from both DeWitt and DeWitt Township is permitted by the Water Resources Commission.

DeWitt Township

This community was given a Final Order of Determination in July, 1966, to abate pollution of the Lookingglass River. Construction has begun on a secondary plant with phosphorus removal. Completion is scheduled for September, 1971. The design flow is 1.6 MGD and the design population is 8,000. A construction grant was awarded to the Township.

Summary

The Lookingglass River is noted for low stream velocity and volume during summer months. Seasonal elevation of temperature occurs and aquatic vegetation growth sometimes is excessive. Six communities have waste discharges into the river. Only one now has treatment adequate to protect the river. Two communities have new waste treatment plants under construction and these will be completed in 1971. The remaining three communities have submitted plans to upgrade existing plants or build new plants. The adequate treatment of all municipal wastes discharged to the river will help to curb the excessive weed growth and enhance water quality.

4. MAPLE RIVER

Ovid

The Village of Ovid, under order from the Water Resources Commission, completed a sewage collection system and stabilization lagoons late in 1969. These facilities were designed to serve 1,600 people and are at or near capacity now. Expansion will probably be necessary in the near future. Flow is .15 MGD and after treatment is discharged to the Maple River.

Elsie

This community of 1,045 presently has no municipal wastewater treatment system. The official plan for Elsie calls for stabilization lagoons and a collection system. Design flow is .127 MGD and design population is 1,270 persons. Elsie has a 1971 grant application pending. At present, there is ample evidence of septic tank failure and subsequent discharge of sewage to the storm sewer system.

Ashley

Ashley, in conjunction with Gratiot County, completed a collection sewer system and stabilization lagoon treatment system in 1970. The community has been under a Final Order of Determination by the Water Resources Commission. Ashley received a 1969 grant to assist with construction costs. The treatment system has a design population of 600 population equivalents and a flow of .06 MGD. Present population now being served is about 500. Discharge from the lagoons is allowed only once annually to Bear Creek a tributary of the Maple River.

Perrinton and Fulton Township

Perrinton and Fulton Township (including the Village of Middleton and the Rainbow Lake Development) are both under Final Order of Determination from the Water Resources Commission to abate pollution of the Maple River. As a result of the orders, both communities are going ahead on a joint treatment system. The system is designed so that about 700 persons can be served in the Village of Middleton and the Rainbow Lake Development combined and 600 persons can be served in Perrinton. Neither area has reached those populations yet. There are 400 platted lots in the Rainbow Lake Subdivision. More than half of these have been sold and 55 homes have been built. Ultimate development plans call for an expansion to 1,300 lots. Before this is realized additional treatment will be necessary. Completion date for the project is scheduled to be June, 1972, as per Commission order. Construction grants have been applied for.

Maple Rapids

The Clinton County Department of Public Works is assisting the Village of Maple Rapids in obtaining funds for sewage treatment facilities. At present the Village is served by septic tanks. Stabilization lagoons are planned with a design population of 800 and a flow of .08 MGD. Maple Rapids presently has a population of 700. A construction grant has been applied for. Construction began in January, 1971, and is scheduled for completion in January, 1972. Treatment will be adequate when these facilities are completed.

Westphalia

Westphalia is presently served by private septic tanks. As is often the case in areas which have a large number of these systems, some become of little or no use in treating sewage. Stony Creek, a tributary of the Maple River, receives the raw or partially treated sewage from this community. Recognizing this, the community has applied for a State and Federal grant to provide a sewage collection system and lagoon type treatment facilities. Westphalia has a present population of about 800. Facilities are designed to serve 1,200.

Crystal Township - Montcalm County

The area around Crystal Lake and the Village of Crystal is served by private septic systems. This has proven to be unsatisfactory because of unsuitable soils. No industry is present. The Township has applied for State and Federal grants to assist them in constructing a sewage collection system and lagoon type treatment. The proposed service area would serve 1,330 people at the present time and is designed to serve 2,290 people by 1990. Design flow is .15 MGD. A semi-annual discharge will be permitted to Fish Creek, a tributary of the Maple River.

Carson City

Carson City had an average flow of .12 MGD of untreated sanitary and industrial waste discharged through storm sewers to Fish Creek. A Final Order of Determination was issued to the City from the Water Resources Commission in January of 1968. Construction was initiated on a waste treatment facility in 1968. A portion of the existing storm sewer system was utilized for collection. The project is now completed and pollution of Fish Creek has been abated. Low flow in Fish Creek at Carson City is 3.3 cfs so only a semi-annual discharge during high flows is permitted. The City received a construction grant for the project.

St. Johns

This city has a secondary waste treatment plant which discharges .80 MGD to Hayworth Creek, a tributary of the Maple River. With the exception of phosphorus content the plant provides adequate treatment. St. Johns is under a Final Order of Determination with the Water Resources Commission to provide 80 percent phosphorus removal by October 1972. The Commission has also entered into a Stipulation for tertiary treatment at St. John.

Fowler

At the present time this community has a secondary trickling filter type waste treatment plant. The effluent, however, is not of a high enough quality to prevent degradation of Peets Creek, a tributary of the Maple River. The original plant built in 1938 and improved in 1958 has a design flow of .04 MGD and has been operating at or above capacity. Project plans include a multi-cell lagoon which will permit semi-annual discharge to Peets Creek at optimum flows. Present population to be served is 1,000 with a design population of 1,500. A slaughter-house contributes a significant BOD load to the plant. Fowler has received grants to assist in construction costs.

Stanton

Stanton has an average flow of .12 MGD. This waste is stabilized in lagoons and discharged twice annually to Fish Creek. The facility was built with the aid of a 1966 Federal grant and is designed to serve 1,300 people. This facility has resulted in improved water quality in Fish Creek.

Lyons-Muir

Neither of these communities has a municipal treatment facility at the present time. Both communities have signed stipulations with the Water Resources Commission agreeing to provide adequate treatment by December 1972. Strict effluent standards are contained in the stipulations. The villages are working together and have proposed a plan to provide an interceptor from Lyons to Muir and construct a lagoon system to serve both communities. Effluent from the system will be discharged to the Maple River twice annually.

Summary

The Maple River is a sluggish stream for much of its length. It flows through mostly underdeveloped or agricultural land. Either directly or via tributary streams the Maple receives the waste effluent from 14 communities. Two of these communities have had adequate treatment for some time and are now

adding additional phases of treatment. Four other communities completed waste treatment facilities in the last three years and now provide adequate protection of the Maple River. Six more facilities are scheduled to be complete at least by December 1972. Some of these are already under construction. Two of the planned systems incorporate two communities.

Waste quality has improved over the last few years and will continue to do so as the necessary treatment for municipal waste is provided.

5. THORNAPPLE RIVER BASIN

Sunfield

This community of 700 has relied on private septic systems until this year. Construction was begun late in 1970 and will soon provide the village with a sewage collection system and stabilization lagoon treatment system. The system was designed to serve 800 people and will discharge to spreading basins with no discharge to Mud Creek, a tributary of the Thornapple River. 1970 State and Federal construction grants were received by the village.

Nashville

In 1964 this community received a grant to construct primary treatment facilities to serve 2,000 people. An Imhoff tank and collecting sewers were installed. The facility currently serves 1,250 people but achieves only 20-30 percent BOD removal and 40 percent suspended solids removal. Average flow from the plant has been .142 MGD, design flow is .200 MGD. In addition, there is an existing interceptor which discharges untreated wastes to Quaker Brook, a tributary to the Thornapple River. Nashville was offered a Stipulation with the Water Resources Commission but to date the City has not signed. Nashville has, however, applied for a 1971 grant to provide phosphorus removal by chemical precipotation. In so doing, BOD and suspended solids removal will be increased. The plant capacity will not be increased. No industrial wastes are treated.

Lake Odessa

This community is one of the few in the State which discharges to an inland lake. The present facility, of the trickling filter type, was built in 1953 and discharges about .30 MGD to Jordan Lake. It was designed to serve 1,200 people but now serves 1,800 people plus the wastes from a canning industry. Wastes from the factory are equivalent to 7,100 people. Lake Odessa was given a Final Order of Determination in August, 1967. The city received a grant in 1968 for construction of an enlarged plant which will provide secondary treatment by activated sludge. This will be complete in September 1971. Design flow of the new facility is 1.0 MGD. Pollution of Lake Jordan will be abated.

Woodland

This village was given a Final Order of Determination in 1959 and in 1960 applied for and received a waste treatment facility construction grant. Secondary treatment followed by sand filtration for the village was then provided. McArthur Drain, a tributary to the Thornapple River, receives the .04 MGD discharge from this plant. Treatment is adequate at this time.

Clarksville

The village of Clarksville presently has no municipal treatment facility. Partially treated waste from individual sptic systems reaches Bean Creek and creates a health hazard. The Water Resources Commission has urged the Village to provide a treatment facility. The Village proposed to construct lagoons and spray irrigation to provide treatment. Design capacity will be 490 people. A grant application has been made.

Hastings

Presently the City provides primary treatment and discharges .40 MGD to the Thornapple River. Hastings signed a Stipulation with the Water Resources Commission agreeing to provide secondary treatment with phosphorus removal. The expansion is designed to serve about 7,500 people, design flow is .6 MGD. The City applied for and received a 1970 State-Federal grant to assist in construction. Final plans have been submitted and approved and construction is underway.

Middleville

Since 1940, Middleville has had runicipal treatment. It has been primary treatment by Imhoff tank. The facility presently serves 1,700 people and an average of .14 MGD is discharged to the Thornapple River. Middleville received a 1969 grant to expand and upgrade their waste treatment facility. Construction began in May, 1970, and is scheduled to be completed in May, 1972. Treatment will consist of oxidation lagoons and spray irrigation. The facility is designed to serve 3,000 and has a design capacity of .3 MGD.

Caledonia

This Village has been served for many years by septic tanks which ultimately are connected to sanitary sewers. The sanitary sewers have

could have been cross connected to storm sewers causing pollution of Emmons Lake. In February, 1970, the Water Resources Commission issued a Final Order of Determination to the Village to abate pollution of Emmons Lake and the Thornapple River. The Village has applied for State and Federal grants to assist in construction of treatment facilities and additional sewers. Preliminary plans have been submitted for approval. The plans call for lagoons and spray irrigation and are designed to serve 1,400 people. Caledonia has a population of 750 at the present time. The high school at Caledonia has its own treatment facility which serves a population equivalent of 425. Treatment is adequate.

Vermontville

This Village of about 780 people had no municipal treatment system prior to 1971. However, under order from the Water Resources Commission, construction was started in February, 1971, on a sewage collection system and stabilization lagoons. Effluent from the lagoons will be disposed of by spray irrigation. The projects were completed recently. The system is designed to serve 1,000 people which should provide service at least through 1990. The project was financed by a State grant and and FHA grant.

Alto (Bowne Township Improvement District #1

At the present time no municipal waste treatment facility exists in Alto. The population is served by private septic tanks. The Village has proposed to provide a sewage collection system and lagoons for sewage treatment. The facility would serve 400 people. Discharge would be only during high flows in Pratt Lake Drain which is a tributary to the Thornapple River. Alto has applied for a 1971 construction grant. The public school would be required to connect.

Potterville

Potterville is served by a wastewater collection system and stabilization lagoons which went into operation in May, 1969. Effluent from the ponds is discharged twice yearly to a county drain which flows to the Thornapple River. Present population is 1,258 and the 1990 population projection is 1,410. The system is designed to serve the City through 1990. Potterville received a State grant to assist in construction of the project.

Summary

General water quality conditions in the Thornapple River are good. Increases in organic material and temperatures below population centers with wastewater discharges have been experienced. These conditions are less frequent than they were a few years ago and will be increasingly less frequent and less severe as existing municipal wastewater treatment plants attain a higher degree of treatment and small communities begin operation of facilities for the first time. The majority of this expansion will be realized in the near future.

Ten communities have discharges to the Thornapple River at this time. Five of them will be or are in the process of upgrading their treatment facilities. One of these five will utilize spray irrigation and so will have no further discharge to the river. Two cities recently completed construction of treatment facilities. Three of the five villages which at present have no municipal treatment system will also use spray irrigation. This will leave six communities discharging to the Thornapple River. All now have plans or construction underway to provide adequate treatment of their wastes.

6. FLAT RIVER BASIN

McBride

The Village of McBride is on the upper reaches of the Flat River. McBride has been told by the Water Resources Commission that a solution to the existing problem must be found. The problem is that many homes are connected to storm drains in the Village allowing untreated sewage to reach surface waters. The Village orginally proposed to have each property owner install acceptable septic tanks since soil conditions are good for this and lot sizes average larger than normal. McBride has now applied for a 1971 construction grant to provide treatment by lagoons for municipal waste. Further staff study is needed.

Edmore

A lagoon type treatment facility was put into operation in 1964 at Edmore. At present, the facility serves about 1,500 people. It has a design capacity of 2,000. A twice yearly discharge is made to Stony Creek, a tributary of the Flat River, and treatment is adequate to prevent degradation. Edmore received a construction grant for the project in 1964.

Greenville

Greenville is located on the Flat River. Its present primary treatment facility serves 8,300 people. The City signed a Stipulation with the Water Resources Commission in April, 1969, agreeing to provide secondary treatment and 80 percent phosphorus removal by December 1972. Since that time final engineering plans have been submitted to the Commission. The plans propose a design flow of 1.5 MGD from a secondary treatment plant utilizing oxidation towers. Design population is 12,000. Construction began in June, 1971. There are no major industrial wastes treated by the municipal system.

Belding

This community of about 5,000 people is achieving good results with their lagoon type waste treatment. The facility was designed to accomodate an average flow of 1.2 MGD and a population of 8,000. Presently the flow treated is .50 MGD. BOD removal achieved when discharging to the river is 92 percent. Suspended solids removal is 90 percent

Belding is somewhat unique in that they have applied for and received a Federal grant to experiment with spray irrigation as a waste treatment method. This program is now underway.

Lowell

A Final Order of Determination was issued to Lowell in 1970 to abate pollution of the Grand River. A primary wastewater treatment plant has been serving the community of 3,000. The plant has achieved a BOD level of 41 mg/l and 46 mg/l of suspended solids. A combined sewage-stormwater flow of .918 MGD flows through the plant.

Lowell has applied for a 1971 grant in order to upgrade the primary treatment and add phosphate removal. By use of FeCl as a precipitator, enough BOD and S.S. will be removed without going to secondary treatment according to their engineering report. Storm sewer flow will be separated from sewage flow and the design flow of the modified facility will be .80 MGD. The design population is 4,100 and construction is scheduled to be completed by December 1, 1972.

Summary

Surface water conditions are generally good in the Flat River Basin. Organic loadings and short term oxygen depressions have been found on occasion below the communities discharging to the Flat. Only five communities discharge to the surface waters in this basin. Two of these communities now have adequate treatment and the other three are committed to providing a higher degree of treatment in the near future.

7. ROGUE RIVER

Casnovia

Casnovia is a community of approximately 400 people located on the upper reaches of the Rogue River. Presently, private septic tanks are used for sewage treatment. Casnovia has applied for a 1971 grant for the purpose of construction of a collection system and lagoons for waste-water treatment. This project has a design population of 560. The Village has a Final Order of Determination from the Water Resources Commission. The Village is in default of that order and the matter has been referred to the Attorney General.

Kent City

Kent City has been served since the mid-1930's by a primary treatment facility. This septic tank and sand filter system was serving about 550 people and was becoming quite inadequate. The community received a 1967 WPC grand and they completed a lagoon system in the year. This waste water treatment facility now handles Kent City's .06 MGD sewage flow and provides adequate treatment to meet water quality standards set for the Rogue River.

Sparta

Treatment is provided by a trickling filter with phosphorus removal. Stormwater overflow has been eliminated.

Algoma Township

At present, Algoma Township residents are served by individual septic tanks. This method is proving to be unsatisfactory due to the amount of seepage from the tanks into Camp Lake. The problem has intensified in recent years due to the increased use of Camp Lake as a residential and recreational area. The Township has a 1971 WPC grant application for funds to assist in the construction of a collection system and lagoons to serve a projected population of 600 in the Camp Lake area.

Sand Lake

This is a small community on the upper reaches of Duke Creek which is a tributary to the Rogue River. Treatment is provided by a lagoon system and is adequate. Discharge from the lagoon is permitted semi-annually. Ultimate needs may require spray irrigation because of the small receiving stream.

Cedar Springs

The Village of Cedar Springs was served until 1970 by a 2 cell oxidation pond built in the 1930's. This facility became inadequate and the community is in the process of building new stabilization lagoons. These lagoons which have a design population of 3,100 are being built with the aid of a 1970 WPC grant. Construction is scheduled for completion in August of 1971. Upon completion, this facility will adequately treat the wastewater of Cedar Springs to meet the water quality standards of Cedar Creek, a tributary of the Rogue River.

Rockford

The Village of Rockford is a part of the North Kent Sewage Disposal System. Rockford's 12,000 plus residents were served by a primary wastewater treatment facility until 1969. In 1969, the village connected to an interceptor system which transports the communities sewage to the Grand Rapids wastewater treatment plant. The interceptor is designed to accomodate and estimated population of 50,000 by the year 2020. Rockford received a 1968 WPC grant for this project.

Summary

The Rogue River is a fast moving, good quality stream. Certain segments of the river have in the past exhibited high fecal coliform-total coliform ratios. Downstream from population centers organic loads are higher. Only six municipalities now discharge to the Rogue River. Three of these communities have upgraded facilities very recently and now adequately protect the river and one is in the process of providing more treatment. Two other villages will be providing adequate treatment in the near future. Water quality will be maintained on the Rogue River.

(b) Industries Discharging to Surface Waters in the Grand River Basin

1. Identification of Industries

Location	Wastewater Control Status
Jackson	
1. Clark Equipment Company	A
2. Dyecast Corporation	A
3. Goodyear Tire and Rubber Company	B
4. LaFere Forge and Machine Company	B
5. Penn Central Railroad	B
6. Pittsburgh Forging Company	D_p
Delta Township	
1. G.M.C. Parts Division	A
Lansing	
1. G.M.C. Olds Forge Division	A
2. John Bean Corporation	B
3. Otto E. Eckert Power Station Lansing Board of Water and Light	D
Fowlerville	
1. Hoover Ball and Bearing Company, Utilex Div.	B
Ovid	
1. Michigan Milk Producers Association	A
Elsie	
1. Hancock Industries, Inc.	B
St. Johns	
1. Federal Mogul Corporation	E_p
Carson City	
1. Vlasic Foods, Inc.	D_s
2. Crystal Refining Company	B
Portland	
1. T.R.W. Inc.	D_c
Ionia	
1. Integral Engineering and Manufacturing Corp.	B
Lowell	
1. Attwood Corporation	B
Saranac	
1. Universal Metal Products	A

Location	Wastewater Control Status
Sparta	
1. Sparta Foundry Company	B
Lyons	
1. Chrysler Corporation Lyons Trim Plant	A
Ada	
1. Ada Beef Company	A
2. Amway Corporation	D_p
Hastings	
1. E.W. Bliss Company	D
2. Hastings Aluminum Products, Inc.	D
3. Hastings Manufacturing Company (2 outfalls)	A^c
Bailey	
1. Vintage Foods	E
Charlotte	
1. Allen Packing Company	A
2. Owens-Illinois Glass Company	E_s
Allendale	
1. Allendale Packing Company	A
Middleville	
1. Bradford White Company	D_s
Sheridan	
1. Carnation Milk Company	A
Edmore	
1. Aunt Janes Foods, Div. of Borden, Inc.	B
Belding	
1. Extruded Metals Company	B
2. Indian Summer Company	A
3. White Consolidated Industries, Gibson Products Division	D_p
Walker	
1. Bissel Inc.	A
2. Bissell Inc., - Indian Mill Creek	D
Ashley	
1. Portec, Inc.	A
Kent City	
1. National Fruit Products Company, Inc.	A
Six Lakes	
1. Michigan Consolidated Gas Company	A

Location	Wastewater Control Status
Cascade Township (Kent County)	
1. Cascade Data Computer Systems	A
Grandville	
1. Jervis Corporation	A
2. Nelson Metal Products, Div of Midland Ross Corp.	A
3. Packaging Corporation of America, American Box Bd. Div.	A
Grandville	
1. Federal Mogul Corporation	A
2. Greenville Fetters Co., Greenville Corp.	E
3. White Consolidated Industries, Gibson Products Div.	E_{sp}
Wyoming	
1. Chesapeak-Ohio R.R. Yards	E_p
2. G.M.C. Diesel Equipment Division	A
3. Kelvinator Incorporated	D
Grand Rapids	
1. Packaging Corporation of America	E_p
Grand Haven	
1. A.S.P. Manufacturing Company	A
2. Challenge Stamping and Porcelain Cpompany	B
3. Eagle Ottawa Leather Company	E_p
4. Grand Haven Stamped Products Company	A
5. Grand Haven Brass Company	E
6. Municipal Power Company	

Total Industries Listed -- 66

A - 28	E Total - 9
B - 15	E - 3
D - Total 13	E_s - 1
D - 5	E_p - 4
D_p - 3	E^p_{sp} - 1
D_s - 2	
D_c - 3	

Subscripts:
- c - construction underway
- p - plans being prepared
- s - studies underway

Annual Rating:
- A - Control adequate
- B - Control provided - Adequacy not fully established
- D - Control provided - unreliable
- E - Control inadequate

b. <u>Water Quality Standards and Protected Uses</u>

Act 245, Public Acts of 1929, as amended, set forth the Michigan Water Resources Commission's authority to establish Intrastate Water Quality Standards and use designation areas. This act reads in part: "An act to create a water resources commission to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the Great Lakes, with power to make rules and regulations governing the same..."

Section 5 and Section 6(a) of this act relate directly to the Commission's authority to adopt regulations to control the pollution of the inland waters of the State as they do to the Interstate waters.

> Sec. 5. "The commission shall establish such pollution standards for lakes, rivers, streams and other waters of the State in relation to the public use to which they are or may be put, as it shall deem necessary."
>
> Sec. 6(a). "It shall be unlawful for any person directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life or plants or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired."

Water quality standards were adopted by the Water Resources Commission on January 4, 1968, for all the waters within the State. The water use designation areas were adopted on March 20, 1969, following a series of public hearings.

The standards for the water quality parameters that relate to each specific use are shown on Table V-7. Once the designated uses for a body of water are known, the most restrictive standards for each parameter can be determined from the table. The most restrictive standards then become the standards necessary to achieve the quality of water required to meet the uses designated.

Table V-6
Water Quality Standards

COMMISSION OBJECTIVE:

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION AND THE DEPARTMENT OF THE INTERIOR THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS; OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED; OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTERSTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

PARAMETERS / WATER USES	1 COLIFORM GROUP (Organisms/100 ml. or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A WATER SUPPLY (1) DOMESTIC Such as drinking, culinary and food processing.	FOR GREAT LAKES & CONNECTING WATERS: The monthly average shall not exceed 2000 nor shall 20% of the samples examined exceed 2200. FOR INLAND WATERS: The monthly average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium[6]: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-8.
(2) INDUSTRIAL Such as cooling and manufacturing process.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
B RECREATION (1) TOTAL BODY CONTACT Such as swimming, water-skiing and skin-diving.	The average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 100.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
(2) PARTIAL BODY CONTACT Such as fishing, hunting, trapping, and boating.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
C FISH, WILDLIFE AND OTHER AQUATIC LIFE Such as growth and propagation.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	At the average low river flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained for: Intolerant fish - cold water species: Not less than 6 at any time. Intolerant fish - warm water species: Average daily DO not less than 5, nor shall any single value be less than 4. Tolerant fish - warm water species: Average daily DO not less than 4, nor shall any single value be less than 3. At greater flows the DO shall be in excess of these values.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D AGRICULTURAL Such as livestock watering, irrigation and spraying.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Not less than 3 at any time.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use.
E COMMERCIAL AND OTHER Such as navigation, hydroelectric and steam generated electric power and uses not included elsewhere in standards.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.

Table V-6 (Cont'd)

* For the Great Lakes and connecting waters no heat load in sufficient quantity to create conditions which are or may become injurious to the public health, safety or welfare; or which are or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which are or may become injurious to the value or utility of riparian lands; or which are or may become injurious to live stock, wild animals, birds, fish or aquatic life or the growth or propagation thereof.

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates, and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 * TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
FOR GREAT LAKES & CONNECTING WATERS: Total Dissolved Solids: The maximum shall not exceed 200. Chlorides: The monthly average shall not exceed 50. A monthly average of 10 is a desirable limit where existing conditions are less than 10. FOR INLAND WATERS: Total Dissolved Solids: Shall not exceed 500 as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 10°F.	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha-emitters and strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range [illegible] with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum.	Maintained within the range [illegible] with a maximum induced variation of [illegible] unit within this range.	Standards to be established when information becomes available on deleterious effects.
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	(Ambient / Allowable increase / Maximum limit) Intolerant fish - cold water species: 32° to nat. max. / 10° / 70° Intolerant fish - warm water species: 32° to 35° / 15°; 36° to nat. max. / 10° / 85° Tolerant fish - warm water species: 32° to 59° / 15°; 60° to nat. max. / 10° / 87°	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0).	Standards to be established when information becomes available on deleterious effects.
Less than 700 dissolved minerals. Maximum percentage of sodium 40% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ when the bases are expressed as milliequivalents per liter.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha-emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.

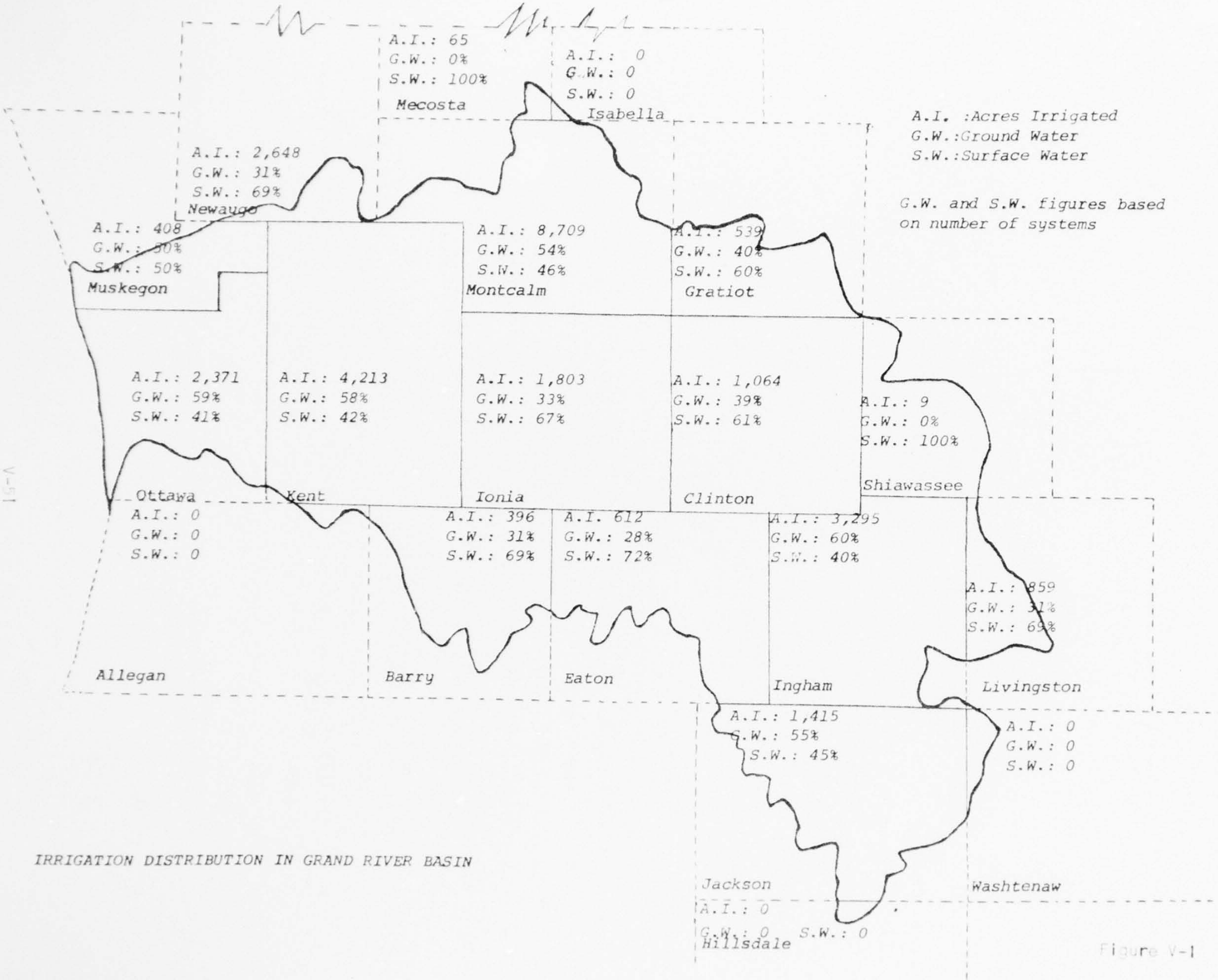
As stated in the Michigan Intrastate Water Quality Standards "the stream flows to which the standards will apply are those equal to or exceeding the 10 year recurrence of minimum low flow average of 7-day duration." This means that the quality will exceed that required for the specified use designation all but a small fraction of the time.

Designated uses for surface waters within the basin will be shown on a separate set of maps, which will be made a part of this report at a later date.

5. Water Uses.

a. Introduction. Water use intensity varies widely in the Grand River basin. Some areas are subject to heavy withdrawals for domestic and industrial water supply and irrigation. In other areas the withdrawal uses are at a minimum but recreational use is intense. Irrigation as a water use also varies widely within the basin.

Five of the ten leading counties in the State in terms of acres irrigated are partially or wholly within the basin. There are a total of 28,406 acres under irrigation in the basin, about 28 percent of the State total. Statewide, the average amount of water applied per acre is 7.5 inches. This gives a total of 119,181 acre inches per year used for irrigation. There are 541 individual irrigators in the basin and 281 rely on groundwater sources for supply while 262 rely on surface water. Figure V-1 shows the irrigation distribution in the Grand River basin.



IRRIGATION DISTRIBUTION IN GRAND RIVER BASIN

Figure V-1

b. Municipal Water Supply

Community growth is dependent to a very large extent upon the continuous availability of an economical supply of potable water. All land use activities, whether they are residential, commercial, industrial or public, possess certain unique and basic water requirements and therefore must locate where the supply is capable of satisfying this demand. Development, regardless of type, occurs where water is economically available.

In planning area WL-08-30, there are a total of 75 communities which have municipal water supply systems. Of the 10 municipalities in the basin relying on surface waters, 2 use inland sources. Rockford gets water from the Rogue River and Grand Rapids uses the Grand River frequently during the summer or when use exceeds Lake Michigan plant capacity. The other 8 use Lake Michigan for water supply. The following discussion (pages V-52 thru V-56) describes municipal water use by river basin.

Grand River Basin

The Grand River Basin, due to its vast land area and because of the large numbers of people and urban centers which it encompasses, has been segmented into eight sub-basins. Data on each of these sub-basins have been collected in a uniform manner, similar to that presented for each basin. Following the sub-basin water consumption segments, a summation of the total Grand River Basin is presented for basin comparison.

Grand River, Main Branch Sub-Basin

There are 34 communities within the Main Branch Sub-Basin which receive their water supply via municipal systems. Of these, 26 are served by groundwater sources, while eight rely upon Lake Michigan. These two supply sources serve 233,548 and 289,182 residents with 14,974.95 and 16,996.35 MGY respectively. The average daily water demand by municipal systems in the sub-basin is 87.59 MGD, while the average daily municipal water use per capita is 168 GPD.

POPULATION SERVED AND CONSUMPTION

Grand River Main Branch Sub-Basin[1]

County	Population Served By Municipal Systems	Consumption by Use Category - MGY Res.	Ind.	Comm.	Instit.
Clinton	900	10.00	-	0.50	-
Eaton	17,200	423.50	68.50	21.00	17.20
Ingham	118,700	2,319.56	3,106.73	1,366.96	423.66
Ionia	15,602	388.81	136.74	50.84	393.06
Jackson	66,744	1,355.76	2,674.02	727.41	641.14
Kent	280,786	5,717.87	4,913.87	3,495.63	395.91
Montcalm	792	16.37	-	5.00	3.00
*Ottawa	22,006	659.10	668.33	69.88	81.36
Sub-Basin Totals	522,730	10,890.97	11,568.29	5,737.22	1,955.33

*Grand Haven receives part of its water supply via the Great Lakes and part from groundwater sources.

1. Total consumption figure includes 1,819.40 MGY of unaccounted water from the City of Grand Rapids

Flat River Sub-Basin

All of the four governmental units which receive their water supply via municipal systems within the Flat River Sub-Basin have groundwaters as their source. These groundwaters supply 16,450 individuals with 1,502.84 MGY. Average daily water demand by municipal systems in the sub-basin is 4.12 MGD, while the average daily municipal water use per capita is 250 GPD.

POPULATION SERVED AND CONSUMPTION

Flat River Sub-Basin

County	Population Served By Municipal Systems	Consumption by Use Category-MGY Res.	Ind.	Comm.	Instit.
Ionia	5,000	102.37	585.98	20.47	13.65
Kent	2,800	87.00	110.00	5.00	1.00
Montcalm	8,650	281.63	268.54	52.18	15.01
Sub-Basin Totals	16,450	471.00	924.52	77.65	29.66

Maple River Sub-Basin

The 11 communities which receive their water supply via municipal systems within the Maple River Sub-Basin all use groundwaters as their source. The groundwaters supply 16,690 residents with 797.29 MGY. Average daily water demand by municipal systems in the sub-basin is 2.18 MGD, while the average daily municipal water use per capita is 131 GPD.

POPULATION SERVED AND CONSUMPTION

Maple River Sub-Basin

County	Population Served By Municipal Systems	Consumption by Use Category - MGY Res.	Ind.	Comm.	Instit.
Clinton	12,318	189.02	285.36	94.85	15.05
Gratiot	921	35.86	1.00	0.84	0.50
Ionia	1,150	36.49	-	-	2.19
Montcalm	2,300	63.51	55.00	10.63	7.00
Sub-Basin Totals	16,689	324.88	341.36	106.32	24.74

Thornapple River Sub-Basin

There are 14,245 residents in the Thornapple River Sub-Basin which receive their water supply from the eight municipal groundwater systems. These systems supply some 937.85 MGY. The average daily water demand by municipal systems in the sub-basin is 2.57 MGD, while the average daily municipal water use per capita is 180 GPD.

POPULATION SERVED AND CONSUMPTION

Thornapple River Sub-Basin

County	Population Served By Municipal Systems	Consumption by Use Category - MGY Res.	Ind.	Comm.	Instit.
Barry	9,795	276.26	401.58	40.93	52.48
Eaton	2,647	46.76	2.78	3.33	4.73
Ionia	1,800	40.00	67.00	1.00	1.00
Sub-Basin Totals	14,242	363.02	471.36	45.26	58.21

Cedar River Sub-Basin

All of the eight governmental units which receive their water supply via municipal systems within the Cedar River Sub-Basin have groundwaters as their source. These groundwaters supply some 49,200 persons with 3,889.63 MGY. Average daily water demand by municipal systems in the sub-basin is 10.66 MGD, while the average daily municipal water use per capita is 217 GPD.

POPULATION SERVED AND CONSUMPTION

Cedar River Sub-Basin

County	Population Served By Municipal Systems	Consumption by Use Category - MGY Res.	Ind.	Comm.	Instit.
Ingham[1]	47,455	1,487.57	390.45	137.26	1,783.10
Livingston	1,751	86.05	0.67	2.84	1.70
Sub-Basin Totals	49,206	1,573.62	391.12	140.10	1,784.80

1. The 40,000 student population at Michigan State University, was not included, due to the transient nature of the student body.

Lookingglass, Rogue, and Portage River Sub-Basins

Comparative data for the ten communities which receive their water supply via municipal systems is noted by basin as follows:

Lookingglass River Sub-Basin

Source of supply	1 groundwater system			
Population served by source	1,370			
Water consumption by source	24.00 MGY			
Water consumption by use category	Res.	Ind.	Comm.	Instit.
MGY	21.50	-	0.50	2.0
Average daily demand by all basin systems	0.07 MGD			
Average daily municipal water use per capita	48 GPD			

Rogue River Sub-Basin

Source of supply	6 groundwater systems; 2 withdrawals from surface waters other than the Great Lakes			
Population served by source	groundwater 13,689 surface waters 2,800			
Water consumption by source	groundwater 553.96 MGY surface waters 138.22 MGY			
Water consumption by use category	Res.	Ind.	Comm.	Instit.
MGY	471.95	138.65	71.68	9.89

Average daily demand by all basin systems 1.90 MGD

Average daily municipal water use per capita 115 GPD

Portage River Sub-Basin

There are presently no communities within the Portage River Sub-Basin which operate a municipal water supply facility.

Grand River Basin - Total

There are 75 communities within the Grand River Basin which receive their water supply via municipal systems. Of these, 64 are served by groundwater sources, eight by Lake Michigan and two rely upon surface waters other than the Great Lakes. These three supply sources serve 345,194; 289,182 and 2,800 basin residents with 22,680.52 MGY, 16,996.35 MGY and 138.22 MGY respectively. The average daily water demand by municipal systems in the basin is 104.10 MGD, while the average daily municipal water use per capita is 163 GPD.

MUNICIPAL WATER SOURCE AND CONSUMPTION

Grand River Basin - Total

County	Population in Basin	Population Served		Consumption by Use Category MGY			
		Municipal Systems-(%)	Individual Wells-(%)	Res.	Ind.	Comm.	Instit.
Allegan	311	-	311(100)	-	-	-	-
Barry	24,438	9,795(40)	14,643(60)	276.26	401.58	40.93	52.48
Calhoun	97	-	97(100)	-	-	-	-
Clinton	37,936	13,218(35)	24,718(65)	199.02	285.36	99.85	15.05
Eaton	35,594	19,847(56)	15,747(44)	470.26	71.38	24.33	21.93
Gratiot	6,979	921(13)	6,058(87)	35.86	1.00	0.84	0.50
Hillsdale	346	-	346(100)	-	-	-	-
Ingham	209,463	166,155(79)	43,308(21)	3,807.13	3,497.18	1,504.22	2,206.76
Ionia	43,165	23,552(55)	19,613(45)	567.67	749.72	72.31	409.5[illegible]
Jackson	118,261	66,744(57)	51,517(43)	1,355.76	2,674.02	727.41	641.14
Kent	361,730	300,075(83)	61,655(17)	6,276.82	5,162.52	3,572.31	406.80
Livingston	5,247	1,751(33)	3,496(67)	86.05	0.67	2.84	1.70
Mecosta	263	-	263(100)	-	-	-	-
Montcalm	28,525	11,742(41)	16,783(59)	361.51	323.54	67.81	25.01
Muskegon	8,563	-	8,563(100)	-	-	-	-
Newaygo	1,571	-	1,571(100)	-	-	-	-
Ottawa	51,181	22,006(43)	29,175(57)	659.10	668.33	69.88	81.36
Shiawassee	11,814	1,370(12)	10,444(88)	21.50	-	0.50	0.20
Washtenaw	461	-	461(100)	-	-	-	-
Basin Totals	945,945	637,176(67)	308,769(33)	14,116.94	13,835.30	6,183.23	3,862.83

c. Industrial Water Supply.

Industrial location also reflects the availability of an economical water supply. Those industries which require large amounts of water for cooling or processing tend to locate near the Great Lakes or their connecting waters. Secondary fabrication and service industries are not so dependent upon a large source of water and consequently tend to locate inland.

Data below was developed to show industries in the basin which rely solely or partially upon private sources.

REGIONAL WATER USE
BY INDUSTRIES USING
PRIVATE SOURCES OF SUPPLY

River Basin	Number Reporting	Consumption by source of supply-MGY Mun.	Ground	Surface	Total Consumption
Grand (Main Branch)	32	978.7	2,365.4	25,100.3	28,444.4
Cedar	3	25.0	213.5	-	238.5
Flat	5	-	588.1	5,764.6	6,352.7
Looking Glass	none reported	-	-	-	-
Maple	2	-	187.0	-	187.0
Portage	none reported	-	-	-	-
Rogue	4	-	97.0	416.0	513.0
Thornapple	2	237.6	83.4	-	321.0
Totals	48	1,241.3	3,534.4	31,280.9	36,056.6

d. Domestic and Industrial Waste Disposal.

Traditionally water has been used as the agent to assimilate and convey wastes generated by municipalities and industries. When the first communities and industries in the basin were established, the surface waters receiving discharges were capable of handling the small loads of wastes generated.

Today, the use of surface waters for waste assimilation competes with other important uses. Wastes discharged without proper treatment may affect public health and conflict with other uses of surface waters. As communities and industries grow, treatment facilities must be improved and modernized to insure that the quality of the water is maintained for all the designated uses.

The information presented in the following table describes municipal and industrial discharges within the basin. This information is arranged by watershed and broken down as to the types of uses protected at or below the discharges. Maps showing the location of discharges within the basin are on the pages following the waste discharge tables.

Table V-7

DESCRIPTION OF MUNICIPAL AND INDUSTRIAL DISCHARGES WITHIN BASIN

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. Other	Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
GRAND RIVER WATERSHED																	
Grand Haven	Municipal	Grand River	A 2 B 2 C 2-4 D	Sanitary	2.25	Primary	1970* #156 19[illegible] #172[illegible]	[illegible]	[illegible]	Equivalent to secondary with phos. removal	Stip. #00061	4/17/69	Compl.	Compl.	[illegible]/1/71	12/1/72	Site rejected. New engineer retained and new site select Final plans due [illegible]/1/71
	A.S.P. & Mfg. Co.	Grand River	A 2 B 2 C 2-4 D	Plating Waste	.08	B 3a++											
	Challenge Porcelain Co.	Grand River	A 2 B 2 C 2-4 D		.09	A 1b++											
	Eagle Ottawa Leather Co.	Grand River	A 2 B 2 C 2-3 D	Tanning Waste	1.40					BOD < 3,000 lbs/day S.S. < 40 mg/1 Cr < 2 mg/1 Coliform < 1000/100 ml pH 6.5 - 9.5	Stip.	5/25/70					Has agreement to connect to Grand Haven - SPRING LAKE SEWER AUTHORITY PROPOSED NEW PLANT
	Grand Haven Stamped Prod. Co.	Warber Drain	A 2 B 2 C 2-4 D	Cooling Water	.002	None				Temp < 85°F Chloroform EXT. SUB < 10 mg/1	O.D. #1112	2/21/68					
	Municipal Power Co.	Grand River	A 2 B 2 C 2-4 D	Cooling	.34	None											
Grand Haven	Grand Haven Brass Company	Grand River	A 2 B 2 C 2-4 D	Plating Acids		None											Discharge to city storm sewer. Given Notice of Determination 6/22/71
Spring Lake	Municipal	Grand River	A 2 B 2 C 1-4 D	Sanitary	.29	Primary IT				**	Stip #00072	3/20/69	Compl.	Compl.	6/1/71	12/1/72	Will connect to Grand Haven S.T.P.
Coopers-ville	Municipal	Deer Creek	A 2 B 2 C 3 D	Sanitary	.33	Secondary IT	1970* #1552 1971 #1760	216	37	Phos. removal			Compl.	Compl.	Compl.	10/1/71	Lagoons under construction
Allendale	Allendale Beef Co.	Bass River	A 2 B 2 C 3 D	Slaughter-house	Int.	Oxidation Ponds											
Bailey	Vintage Foods, Inc.	Crockery Creek	A 2 B 2 C 2,3 D	Food Proc.	.05												
Ravenna	Municipal	Crockery Creek	A 2 B 2 C 2,3 D	Sanitary	.02	Secondary (Lagoon)	1969* #1358			Treatment adequate	F.O.D. #1152	4/25/68	Compl.	Compl.	Compl.	Compl.	

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	RECEIVING Protected Uses	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OF FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	Preli. Plans	Final Plans	Const.	Proj. Compl.	REMARKS
Walker	Bissell, Inc.	Indian Mill Creek	A 2 B 2 C 2,3 D		.03					Cr 2 ppm Cu 1 ppm Ni 2 ppm pH 6.5-9.5	O.D. #260	[illegible]/26/58					
Grand-ville	Municipal	Grand River	A 2 B 2 C 2-4 D	Sanitary	.85	Secondary AS	1963* #577 1970 #1591 1971 #1883	27	3	Phos. removal	Stip. #00109	7/22/69	Compl.	Compl.	6/1/71	12/1/72	Also serve City of Hudsonville and Georgetown Township (Ottawa County)
	Packaging Corp. of America American Box Board Div.	Roy Creek Drain	A 2 B 2 C 2,3 D	Machine wash water		Settling basins											
	Jarvis Corp.	Grand River	A 2 B 2 C 2-4 D	Plating Waste	.78	B 1b++											
	Nelson Metal Prod.	Buck Creek	A 2 B 2 C 3 D	Cooling Water & Oils		Skimmer				Ether Ext. Sub. 10 mg/1 S.S. 30 mg/1	O.D. #895	7/21/68					
Byron Twp. (Byron Center)	Municipal	Buck Creek	A 2 B 2 C 3 D	Sanitary	.20	Secondary (Lagoon)				Treatment adequate							
Wyoming	Municipal	Grand River	A 2 B 2 C 2-4 D	Sanitary	5.50	Secondary TF	1962* #537 1971 #1734	26	2	Phos. removal	Stip. #00122	9/1/69		See 1971 Grant Application #1734			
	Chesapeake-Ohio R.R.	Grand River	A 2 B 2 C 2-4 D	Oil		Separator											
	GMC Diesel Equip. Div.	Plaster Creek	A 2 B 2 C 3 D	Oil Plating Waste	2.12	B 3a++				Cr 3 mg Total Cu 2 mg/1 2 lbs/day CN .25 mg/1 .125 lbs/day							
	Kelvinator Inc.	Plaster Creek	A 2 B 2 C 3 D	Oils		None											
	Hoover Ball & Bearing (Formerly Reynolds Aluminum)	Grand River	A 2 B 2 C 2-4 D			Secondary (Lagoon)				Treatment adequate							
Grand Rapids	Municipal	Grand River	A 2 B 2 C 2-4 D	Sanitary	44.0	Secondary AS	1970* #1546 1971 #1724	73	11	Phos. removal	O.D. #453 Stip. #00095	5/25/62 6/24/69	Compl.	Compl.	6/1/71	12/1/72	

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
	Packaging Corp. of America	Grand River	A 2 B 2 C 2-4 D	Cooling Paper Wastes	2.5												Propose to connect to Grand Rapids S.T.P. by March, 1972
	Jet Electronics & Technology, Inc.	Grand River	A 2 B 2 C 3 D	Sanitary		Secondary (Lagoon)				BOD < 40 mg/l SS < 60 mg/l coliform < 1000/100 ml Ether Ext. Sub < 10 mg/l	O.D. #915 O.D. #934	8/24/66 10/27/66					
Ottawa Co. (Eastmanville)	Ottawa Co. Infirmary	Grand River	A 2 B 2 C 2,3,4 D	Sanitary		Septic Tank	1970* #1514			Equivalent to secondary with phos. removal			Compl.	Compl.			Lagoon with spray irrigation
Ottawa Co.	Municipal 1.Grand Valley State 2.Allendale Twp. 3.Georgetown Twp.	Grand River	A 2 B 2 C 2,3,4 D	Sanitary		Secondary (lagoons)	1971 #1731	209	35	Equivalent to secondary with phos. removal			See 1971 Grant Application #1731				Plan lagoon expansion with spray irrigation
Kent Co.	Kent Co. Airport	Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary	.50	Secondary (Lagoon)				Treatment adequate							
Paris Twp. (Kent Co.)	Kroger Co.	Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary	.02					11/15 - 4/15 BOD < 30 ppm SS < 40 ppm 4/16 - 11/14 BOD < 10 ppm SS < 10 ppm pH 6.5 - 10.3 Chloroform EXT Sub < 15 ppm	O.D. #217	7/26/56					
Cascade Twp. (Kent Co.)	Stephenson-Lawyer, Inc.	Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary	.01	Sand Filter				11/15 - 4/15 BOD < 25 mg/l S.S. < 25 mg/l	O.D.	11/30/61					
	Cascade Data Computer Systems	Little Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary	.005	Lagoon				Treatment adequate							
Kentwood	Municipal	Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary		Private Septic Tanks	1971 #1860	108	15	Equivalent to secondary with phos. removal			See 1971 Grant Application #1860				Pinnebrook Interceptor to Wyoming S.T.P.
Gaines Twp. (Kent Co.)	Municipal 1.Gaines Twp. 2.Dutton	Plaster Cr.	A 2 B 2 C 2,3 D	Sanitary		Private Septic Tanks	1970* #1592 1971 #1900	111	16	Equivalent to secondary with phos. removal	F.O.D. #1344	2/19/70	Compl.	Compl.	Compl.	12 /71	Interceptor to Wyoming S.T.P.
Wright Township (Ottawa Co.)	Municipal	Grand River	A 2 B 2 C 2-4 D	Sanitary		Secondary (Lagoon)	1968* #1368			Treatment adequate							

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	RECEIVING Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
Cannon Twp. (Kent Co.)	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary		Private Septic Tanks	1971 #1931	[illegible]	21	Equivalent to secondary with phos. removal			See 1971 Grant Application #1931				Interceptor to Grand Rapids S.T.P.
Ada Twp. (Kent Co. DPW)	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.50	Secondary (Lagoons)	1971 #1899	187	28	Expansion of lagoons			See 1971 Grant Application #1899				
	Amway Corp	Grand River	A 2 B 2 C 2,3 D	Organics & Chemicals	.288	Lagoon				Treatment adequate	O.D. #665	7/23/64					Discharge from March 15-May 15 and November 1-December 1 only
Ada	Ada Beef Co.	Grand River	A 2 B 2 C 2,3 D	Slaughter-house													
Saranac	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.11	Secondary (Lagoon)	1967* #1011			Treatment adequate	O.D. #159	7/29/54					
	Saranac Mfg. Co.	Grand River	A 2 B 2 C 2,3 D	Plating Wastes							O.D. #159	7/29/54					
	Universal Metal Prod.	Grand River	A 2 B 2 C 2,3 D	Cleaner Wastes & Runoff	.20												
Ionia	Municipal 1. Ionia 2. Mich. Reforma-tory & State Hospital	Grand River	A 2 B 2 C 2,3 D	Sanitary	1.40 .60	Primary	1965* #516 1971 #1845	118	18	Equivalent to secondary with phos. removal	Stip. #00094	5/16/69	See 1971 Grant Application #1845				
	Integral Eng. & Mfg.	Prairie Creek	A 2 B 2 C 2,3 D	Cooling & Sanitary	Seepage	Septic Tanks				Groundwater disposal	O.D. #1380	6/25/70					
Portland	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.50	Primary	1957* #27 1971 #1803	35	6	Equivalent to secondary with phos. removal	F.O.D. #1256	4/17/69	Compl.	Compl.	6/1/71	12/1/72	

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses+	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
Portland	T.R.W., Inc.	Grand River	A 2 B 2 C 2,3 D	Cooling Water, Oil, Sanitary	.062	Oxidation Ponds and Oil Skimmer				S.S. < 35 mg/1 Phos < 1 mg/1 pH 6.5 - 9.0 Coliform < 1000/100ml	Stip. #00178	12/17/70	4/1/71	6/1/71	7/1/71	10/1/71	
Sheridan	Carnation Milk Co.	Prairie Cr.	A 2 B 2 C 1-3 D	Dairy	.50	C 2b++				Treatment adequate							
Mulliken (Eaton Co. BPW)	Municipal	Hale & Post Dr. to Grand Dr.	A 2 B 2 C 2,3 D	Sanitary		Private Septic Tanks	1970* #1529 1971 #1869	172	26			Compl.	Compl.	Compl.		91/1/71	Lagoon under constructic Semi-annual discharge
Grand Ledge	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.65	Primary	1957* #14 1968* #1191 1970* #1636 1971 #1856	76	12	Equivalent to secondary with phos. removal	Stip. #00127	12/11/69	Compl.	6/1/71	7/1/71	12/1/72	
Lansing	Municipal	Grand River	A 2 B 2 C 3 D	Sanitary & Industrial	24.0	Secondary AS	1964* #575 1965* #813 1967* #1030 1970* #1372 1971 #1846	102	13	ADVANCED TREATMENT Phos. REMOVAL	F.O.D. #1E [illegible] Stip. #00110	6/25/71 7/22/69	[illegible]	2/1/73	5/1/73	12/[illegible]/74	
	G.M.C. Oldsmobile Forge Div.	Grand River	A 2 B 2 C 3 D	Solids, Oils		A 1b, B 1b, B 2a				Treatment adequate							
	G.M.C. Oldsmobile Div.#3				.75	Connected to Lansing S.T.P.					O.D. #320	2/24/60					
	Board of Water & Light (Eckert Station)	Grand River	A 2 B 2 C 3 D	Cooling Waters		Filters				Treatment adequate							
	John Bean Corp.	Red Cedar River	A 2 B 2 C 3 D	Oil						Treatment adequate							
Dimondale (Eaton Co.DPW)	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.09	Secondary AS with seepage lagoons	1968* #1357			Equivalent to secondary with phos. removal	F.O.D. #957	1/19/67	Compl.	Compl.	Compl.	Compl.	Overflow pipe to river

Table V-7 (Cont'd)

MAP #	LOCATION	SOURCE	RECEIVING WATERS	RECEIVING Protected Uses+	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
	Eaton Rapids	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.75	Primary				Equivalent to secondary with phos. removal	F.O.D. #1255	4/17/69	Compl.	3/1/71	9/1/71	10/1/72	
	Delta Twp. (Eaton Co. BPW)	Municipal	Grand River	A 2 B 2 C 3 D	Sanitary	1.10	Secondary AS	1970* #1605 1971 #1761	31	4	Phos. removal	Stip. #00099	6/24/69	Compl.	Compl.	Compl.	12/1/72	
		GMC Oldsmobile Div.	Jenne Dr. to Grand R.	A 2 B 2 C 3 D	Bonderite Waste	.07	Clarifier				pH 7.0-10.0, Cr^{+6} or Cr^{+3} < 1ppm	O.D. #320	2/24/60					
	Delhi Twp. (Ingham Co.)	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	.33	Primary				Equivalent to secondary with phos. removal	F.O.D. #1257	3/17/69	Compl.	1/1/71	3/1/72	12/1/72	
	Leslie	Municipal	Huntoon Creek	A 2 B 2 C D	Sanitary	.35	Primary				**	O.D. #79	7/25/51					
	Jackson	Municipal	Grand River	A 2 B 2 C 3 D	Sanitary	10.5	Secondary AS	1970* #1542 1971 #1887	218	18	Phos. removal Any additional	O.D. #545	7/25/63					Expansion under construction
		Clark Equipment Company	Grand River	A 2 B 2 C 2,3 D	Oils		Oil separation settling pond				Treatment adequate							
		LaFere Forge and Machine Co.	Grand River	A 2 B 2 C 2,3 D	Oils, Solids	.26	A 1b++				Treatment adequate							
		Penn Central R.R.	Grand River	A 2 B 2 C 2,3 D	Oils	.07												
		State Prison of Southern Michigan	Grand River	A 2 B 2 C 3 D	Sanitary	1.00	Secondary TF with effluent lagoons				Treatment adequate							No discharge during summer months
		Pittsburgh Forging Co.	Grand River	A 2 B 2 C 3 D	Oils, S.S.	.07	Oil skimmer settling tank				Treatment must be upgraded to meet standards							
		Richardson Asphalt Co.	Grand River	A 2 B 2 C 3 D	S.S.		Settling Tanks				Treatment must be upgraded to meet standards							

AD-A043 988 GRAND RIVER BASIN COORDINATING COMMITTEE DETROIT MI F/G 8/6
GRAND RIVER BASIN MICHIGAN. COMPREHENSIVE WATER RESOURCES STUDY--ETC(U)
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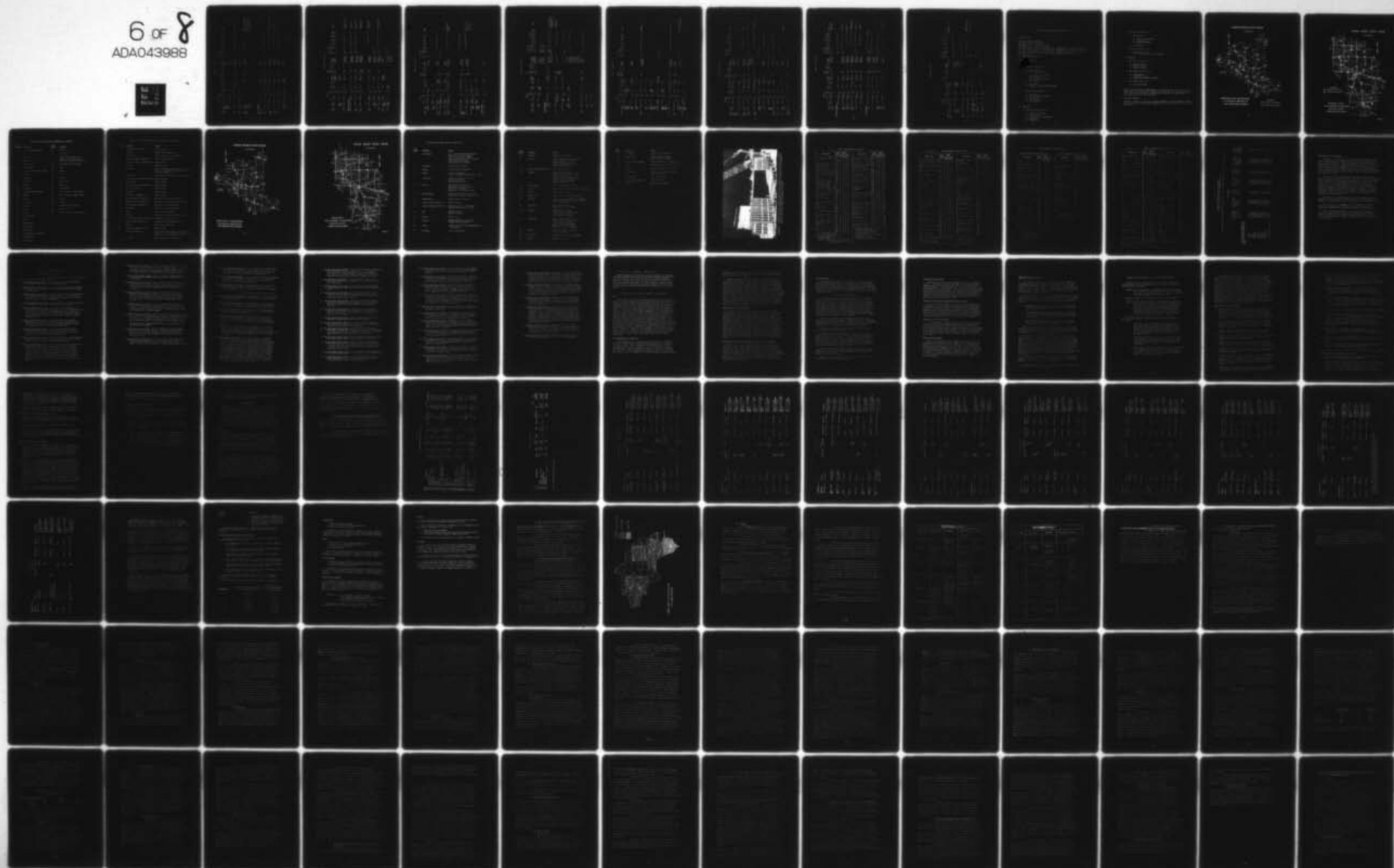


Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED.	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	Preli. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
Jackson	Goodyear Tire & Rubber Company	Grand River	A 2 B 2 C 3 D	Cooling						Treatment adequate							
	Dyecast Corp.	Grand River	A 2 B 2 C 3 D	Oils						Treatment adequate							
Grass Lake	Municipal	Grand River	A 2 B 2 C 3 D	Sanitary	Seep-age	Private Septic Tanks	1970 #1607 1971 #1732	213	35	Equivalent to secondary with phos. removal			See 1971 Grant Application #1732				Lagoons planned
Spring Arbor	Spring Arbor College	Sandstone Creek	A 2 B 2 C 1-3 D	Sanitary		Lagoon				Treatment adequate							
Jackson County (Jackson Metro Area)	Municipal 1. Blackman Twp. 2. Summit Twp. 3. Spring Arbor Twp. 4. Leoni Twp.	Grand River	A 2 B 2 C 3 D	Sanitary	P	Private Septic Tanks	1970 #1588 1971 #1866	188	29	Equivalent to secondary with phos. removal			See 1971 Grant Application #1866				Blackman and Summit Townships and parts of Spring Arbor and Napoleon Townships plan interceptor sewers to the Jackson WWTP. Leoni Township plans a lagoon and spray irrigation system
ROGUE RIVER WATERSHED																	
Sand Lake (Kent Co. DPW)	Municipal	Flat River	A 2 B 2 C 2,3 D	Sanitary	.04	Secondary (Lagoon)	1966* #958			Treatment adequate							
Rockford	Municipal	Rogue River	A 2 B 2 C 1-3 D	Sanitary	.48	Connected to Grand Rapids S.T.P.	1968* #1193			Treatment adequate	O.D. #118	2/26/52	Compl.	Compl.	Compl.	Compl.	
Algoma Twp. (Kent Co.)	Municipal	Camp Lake	A 2 B 2 C 1-3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1885	156	24	Equivalent to secondary with phos. removal			See 1971 Grant Application #1885				Lagoons planned, semi-annual discharge
Cedar Springs	Municipal	Cedar Creek	A 2 B 2 C 1-3 D	Sanitary	.50	Secondary (Lagoons)	1970* #1589			Equivalent to secondary with phos. removal			Compl.	Compl.	Compl.	4/1/71	Lagoon expansion under construction
Kent City	Municipal	Rogue River	A 2 B 2 C 1-3 D	Sanitary	.06	Secondary (Lagoons)	1967* #1010			Treatment adequate			Compl.	Compl.	Compl.	Compl.	
	National Fruit Prod., Co. Inc.	Ball Creek	A 2 B 2 C 1-3 D	Fruit Process	.10	Secondary (Lagoons & Spray Irrig.)				Treatment adequate							

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	RECEIVING Protected Uses	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	Preli. Plans	Final Plans	Start Plans	Proj. Compl.	REMARKS
Sparta	Municipal	Rogue River	A 2 B 2 C 1-3 D	Sanitary	.27	Secondary TF and phos. removal	1967* #1120			Treatment adequate	O.D. #117	2/[illegible]/52	Compl.	Compl.	Compl.	Compl.	
	Sparta Foundry Company	Rogue River	A 2 B 2 C 1-3 D	Oils		Oil Skimmer Lagoons											
Casnovia	Municipal	Ball Creek	A 2 B 2 C 1-3 D	Sanitary		Private Septic Tanks	1971 #1738	134	20	Equivalent to secondary with phos. removal	F.O.D. #.204	9/19/68	Compl.	Compl.	4/1/70	5/1/71	In default of Order Referred to Attorney General
THORNAPPLE RIVER WATERSHED																	
Caledonia	Municipal	Thornapple River	A 2 B 2 C 2,3 D	Sanitary	.074	Primary ST	1971 #1720	104	14	Equivalent to secondary with phos. removal	F.O.D. #1345	2/18/70	Compl.	7/1/71	10/1/71	12/1/72	Lagoon and spray irrigation
Lake Odessa	Municipal	Jordan Lake	A 2 B 1 C 2,3 D	Sanitary	.30	Secondary TF	1968* #1335			May 1 - Oct. 31 BOD 15 mg/1 Nov. 1 - April 31 BOD 30 mg/1	F.O.D. #1041	8/29/67	Compl.	Compl.	Compl.	9/1/71	Spray irrigation under construction
Clarks-ville	Municipal	Bean Creek	A 2 B 2 C 1-3 D	Sanitary		Private Septic Tanks	1970 #1564 1971 #1716			Equivalent to secondary with phos. removal							Lagoons and spray irrigation planned
Middle-ville	Municipal	Thornapple River	A 2 B 2 C 2,3 D	Sanitary	.12	Primary IT	1969* #1392			Equivalent to secondary with phos. removal			Compl.	Compl.	Compl.	5/1/71	Lagoons and spray irrigation under construction
	Bradford White Prod. Corp.	Thornapple River	A 2 B 2 C 2,3 D	Oils	.01	Skimmer				pH 6.5-10.3 SS 50 ppm ether EXT. Sub 15 ppm	O.D. #404	10/26/61					
Hastings	Municipal	Thornapple River	A 2 B 2 C 2,3 D	Sanitary	.40	Primary	1970* #1509			Equivalent to secondary with phos. removal	Stip. #00075	3/20/69	Compl.	Compl.	Compl.	12/1/72	Secondary treatment under construction
Barry County	Barry County Medical Facility	Thornapple River		Sanitary		Secondary (Lagoons with spray irrig.)				Treatment adequate							
Hastings	Hastings Aluminum Prod. Inc	Falls Creek	A 2 B 2 C 2,3 D	Metal Cleaners & Paint	.02	B 1b++				Cr^{+6} .5 mg/1 Cr^{+3} 1.5 mg/1 Phos. 5 mg/1 Chloroform EXT. Sub 10 mg/1 S.S. 20 mg/1 pH 6.5-9.5	O.D. #1300	9/17/69					

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	Preli. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
	Hastings Mfg. Co.	Butter Creek	A 2 B 2 C 2,3 D	Metal Cleaners	.18	B 1b++				pH 6.5-9.5 Cr 5 ppm SS 30 ppm	O.D. #410	11/[illegible]/62					
	E.W. Bliss Company	Thornapple River	A 2 B 2 C 2,3 D	Oils	.18												
Potterville	Municipal	Thornapple River		Sanitary		Secondary (Lagoons)	1968* #1038			Treatment adequate			Compl.	Compl.	Compl.	Compl.	
Woodland	Municipal	McArthur Dr. to Thornapple River	A 2 B 2 C 2,3 D	Sanitary	.04	Secondary TF and S.F.	1960* #328			**	F.O.D. #283	1/28/59					
Vermontville	Municipal	Thornapple River		Sanitary		Secondary (Lagoons)	1969* #1377			Treatment adequate							
Sunfield (Eaton Co.BPW)	Municipal	Mud Creek to Thornapple River	A 2 B 2 C 2,3 D	Sanitary	Seepage	Private Septic Tanks	1970* #1571 1971 #1878	128	19	Equivalent to secondary with phos. removal			See 1971 Grant Application #1878				Lagoons and seepage basins under construction
Bowne Twp. Imp. Dist.#1 (Kent County)	Municipal	Coldwater River	A 2 B 2 C 1-3 D	Sanitary	Seepage	Private Septic Tanks	1970 #1666 1971 #1910	189	30	Equivalent to secondary with phos. removal			See 1971 Grant Application #1910				
Nashville	Municipal	Thornapple River	A 2 B 2 C 2,3 D	Sanitary	.14	Primary	1964* #565 1971 #1838	207	34	Equivalent to secondary with phos. removal			See 1971 Grant Application #1838				Effluent Req'nts $BOD_5 \le 45$ mg/L SS ≤ 35 mg/L pH 6.5 – 8.5 Phos. – max (80% min)
Charlotte	Allen Packing Company	County Dr. to Thornapple River	A 2 B 2 C 2,3 D	Slaughterhouse	.02	A 1b++											
	Owens-Illinois Glass Company	Butternut Creek	A 2 B 2 C 2,3 D	Oils Solids		Oil Skimmer											
FLAT RIVER WATERSHED																	
Belding	Municipal	Flat River	A 2 B 2 C 2,3 D	Sanitary	.50	Secondary (Lagoons)	1965*			Treatment adequate							

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses+	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED.	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	COMPLIANCE DATES Prel. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
Lowell	Municipal	Grand River	A 2 B 2 C 2,3 D	Sanitary	1.00	Primary	1966* #923 1971 #1728	191	31	Equivalent to secondary with phos. removal	F.O.D. #1338	1/15/70	Compl.	5/1/71	10/1/71	12/1/71	
	Attwood Corp.	Flat River	A 2 B 2 C 2,3 D	Electro-plating Wastes	.40	B 3a++				SS 30 mg/1 pH 6.5-9.5 CN 3 mg/1 Cu 5 mg/1 Cr^{+3+6} 10 mg/1 Ni 10 mg/1 Cd 5 mg/1	O.D. #348 O.D. #525 Stip. #00045	12/15/60 6/26/63 3/15/68					
MAPLE RIVER WATERSHED																	
Muir	Municipal 1.Muir 2. Lyons	Maple River	A 2 B 2 C 2,3 D	Sanitary		1&2. Private Septic Tanks	1971 #1924	200	33	S.S. < 35 mg/1 phos < 20% pH 6.5-9.5 Coliform < 1000/100ml BOD < 10 mg/1/cfs	1.Stip #00157 2.Stip #00158	8/24/70 7/23/70	9/15/70 9/15/70	9/1/71 9/1/71	10/1/71 10/1/71	12/1/72 12/1/72	Lyons is constructing an interceptor to Muir which is constructing a lagoon system to serve both communities
Fowler	Municipal	Poets Creek to Maple River	A 2 B 2 C 2,3 D	Sanitary	.05	Secondary TF	1958* #102 1963* #610 1970* #1524			Phos. removal			Compl.	Compl.	Compl.	6/1/71	Lagoons under construction
St. Johns	Municipal	Hayworth Creek	A 2 B 2 C 2,3 D	Sanitary	.80	Secondary TF				Phos. Removal	F.O.D. #1386		7/1/71	1/1/72	4/1/72	10/1/72	
	Federal-Mogul Corp.	Hayworth Creek	A 2 B 2 C 2,3 D	Plating Waste	.62					Advanced Treatment BOD < 4 mg/1 SS < 15 mg/1 Chloroform EXT Sub < 10 mg/1 Phos < 1 mg/1 Cr < .1 mg/1 Pb < .1 mg/1 CN < .025 mg/1 Cu < .01 mg/1 Zn < 01 mg/1 DO > 5 mg/1 Fluoride < 1 mg/1 pH 6.5-910	Stip.	2/18/71		9/1/71	3/1/72	6/1/72	
Carson City	Municipal	Maple River	A 2 B 2 C 2,3 D	Sanitary	.12	Secondary (lagoons)	1970* #1136			Treatment adequate	F.O.D. #1102	1/17/68	Compl.	Compl.	Compl.	Compl.	
	Crystal Refinery Co.	Fish Creek	A 2 B 2 C 2,3 D	Oils	.04	A 1b++											
	Vlasic Foods, Inc.	Fish Creek	A 2 B 2 C 2,3 D	Brine	INT												

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	Prel. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
	Gibson Prod. Div. White Consoli-dated Industry	Flat River	A 2 B 2 C 2,3 D	Oils, Acid & Alkaline Substances, $ZnPo_4$, Cr.	.30	Separation											
	Indian Summer Inc.	Flat River	A 2 B 2 C 2,3 D	Food Proc.	.41	Lagoon with spray irrig.				Treatment adequate							
	Extruded Metals Corp.	Flat River	A 2 B 2 C 2,3 D	Oils		Oil Flotation											
Green-ville	Municipal	Flat River	A 2 B 2 C 2,3 D	Sanitary	1.05	Primary	1970* #1567			Equivalent to secondary with phos. removal	Stip. #00082	4/17/69	Compl.	Compl.	Compl.	12/1/72	Secondary TF under construction
	Federal Mogul Corp.	Flat River	A 2 B 2 C 2,3 D	Plating	.30	B 1b, B 2a++											
	Gibson Prod. Div., White Consoli-dated Industry	Flat River	A 2 B 2 C 2,3 D	Bonder-izing Waste	.50	Lagoons											
	Ore-Ida Foods, Inc.	Dickerson Creek	A 2 B 2 C 2,3 D	Food		Clarifying Pond Spray Irrigation					O.D. #681	9/23/64					
	Ranney Refrig-eration Co. Greenville Petters Corp.	Flat River	A 2 B 2 C 2,3 D	Metal Cleaners	.01	Lagoons											
McBride	Municipal	Flat River	A 2 B 2 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1908	197	32	Equivalent to secondary with phos. removal			See 1971 Grant Application #1908				Lagoons planned
Edmore	Municipal	Flat River	A 2 B 2 C 2,3 D	Sanitary	.12	Secondary (Lagoons)	1964* #568			Treatment adequate							
	Aunt Jane's Foods, Div. of Bordens Company	Flat River	A 2 B 2 C 2,3 D	Pickle Proc.	.02	A 1d Lagoons with spray irrigation				CR 500 ppm pH 6.0-9.5 BOD 40 lbs/day	O.D. #1002	6/28/67					Discharge limited to March 15-April 15. Restrictions on spra irrigation: Cl 25 ppm, pH 6.5-
Six Lakes	Michigan Consoli-dated Gas Company	First Lake at Six Lake Drain	A 2 B 1 C 2,3 D	Cooling	20.0	None											

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Order	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
Crystal Twp. (Mont-calm Co. Dist.#1)	Municipal	Fish Creek	A 2 B 2 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks	1970 #1667 1971 #1909			Equivalent to secondary with phos. removal							
Stanton	Municipal	Fish Creek	A 2 B 2 C 2,3 D	Sanitary	.12	Secondary (Lagoon)	1966* #1002			Treatment adequate							
Maple Rapids (Clinton Co. DPW)	Municipal	Maple River	A 2 B 2 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks	1970* #1601			Equivalent to secondary with phos. removal			Compl.	Compl.	Compl.	5/1/71	Lagoons under construction
Perrington (Gratiot Co.)	Municipal	Pine Creek	A 2 B 2 C 1-3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1740	45	8	BOD < 4 mg/1 NH_3-N < .5 mg/1 D.O. < 80% SAT. S.S. < 15 mg/1 Coliform < 1000/100 ml	F.O.D. #1362	4/15/70		4/1/71	7/1/71	6/1/72	Lagoon planned
Elsie (Clinton Co. DPW)	Municipal	Maple River	A 2 B 2 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1841	177	27	BOD < 10 lbs/cfs			See 1971 Grant Application #1841				Lagoon planned Semi-annual discharge
	Hancock Industries Inc.	Maple River	A 2 B 2 C 2,3 D	Cooling & Sanitary		Septic Tank for Sanitary					O.D. #1270	6/23/69					
Ovid	Municipal	Maple River	A 2 B 2 C 2,3 D	Sanitary	.15	Secondary (Lagoons)	#1107			Treatment adequate	F.O.D. #907	7/28/66	Compl.	Compl.	Compl.	Compl.	
	Mich. Milk Prod. Assoc.	Maple River	A 2 B 2 C 2,3 D	Dairy Proc.	.50	Lagoon with Spray Irrigation				Treatment adequate	F.O.D. #489	11/29/62					
Ashley (Gratiot Co.)	Municipal	Bear Creek	A 2 B 2 C 2,3 D	Sanitary		Secondary (Lagoon)	1969* #1349			Treatment adequate	F.O.D. #1043	8/29/67	Compl.	Compl.	Compl.	Compl.	
Ashley	Portec, Inc.	Maple River	A 2 B 2 C 2,3 D	Cooling	.007					Treatment adequate	O.D. #851	3/30/66					
Lyons	Chrysler Corp. Trim	Grand River	A 2 B 2 C 2,3 D	Sanitary	.002	Secondary				SS 50 mg/1 BOD 50 mg/1 Coliform 1000/100 ml							Lagoons under Construction
Westphalia (Clinton County DPW)	Municipal	Stoney Creek	A 2 B 2 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks.	1970* #1513			Equivalent to secondary with phos. removal							

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	Final Plans	Start Const.	Proj. Compl.	REMARKS
Fulton Twp. (Gratiot Co.)	Municipal	Otto and Pine Creeks	A 2 B 2 C 1-3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1944	44	7	Equivalent to secondary with phos. removal	F.O.D. #1363	4/15/70		4/1/71	7/1/71	6/1/72	Lagoons planned Includes Middleton and Rainbow Lake
LOOKING GLASS RIVER WATERSHED																	
DeWitt	Municipal	Looking Glass River	A 2 B 2 C 2,3 D	Sanitary	.06	Primary				**	F.O.D. #418	1/25/62	Compl.	Compl.	Compl.	Compl.	
DeWitt Twp. (Clinton Co.)	Municipal	Looking Glass River	A 2 B 2 C 2,3 D	Sanitary	.76	Private Septic Tanks	1967* #1047			Equivalent to secondary with phos. removal	F.O.D. #908	7/28/66	Compl.	Compl.	Compl.	9/1/71	Secondary AS under construction
Watertown Twp. (Clinton Co.)	Municipal	Looking Glass River	A 2 B 2 C 2,3 D	Sanitary		Private Septic Tanks	1971 #1843	113	17	Equivalent to secondary with phos. removal			See 1971 Grant Application #1843				Interceptor to the DeWitt S.T.P.
Bath Twp. (Clinton Co.)	Municipal	Park Lake	A 2 B 1 C 2,3 D	Sanitary	Seep-age	Private Septic Tanks	1971 #1842	155	23	Equivalent to secondary with phos. removal			See 1971 Grant Application #1842				Lagoon and interceptor to Park Lake planned
Laingsburg	Municipal	Looking Glass River	A 2 B 2 C 2,3 D	Sanitary	.10	Private Septic Tanks	1970* #1582			Equivalent to secondary with phos. removal	F.O.D. #1154	4/25/68	Compl.	Compl.	Compl.	9/1/71	Lagoon system under construction
Perry	Municipal	Looking Glass River	A 2 B 2 C 2,3 D	Sanitary	.16	Private Septic Tanks	1970* #1312			Equivalent to secondary with phos. removal			Compl.	Compl.	Compl.	7/1/71	Lagoons under construction
RED CEDAR RIVER WATERSHED																	
East Lansing	Municipal	Red Cedar R.	A 2 B 2 C 3 D	Sanitary	10.0	Secondary AS	1964* #714 1971 #1823	54	10	Phos. removal Advanced Treatment	Stip. #00118 Stip. #00197	8/14/69 6/22/71	Compl.	8/1/71	12/1/71	12/1/72 12/1/74	
Mason	Municipal	Sycamore Creek	A 2 B 2 C 2,3 D	Sanitary	.45	Secondary AS	1958* #132 1971 #1802	160	25	Phos. removal Advanced Treatment	Stip. #00125	10/16/69	Compl.	12/1/70	8/1/71	12/1/72	
Williamston (Ingham Co. DPW)	Municipal	Red Cedar R.	A 2 B 2 C 2,3 D	Sanitary	.24	Primary	1970* #1566 1971 #1871	32	5	Equivalent to secondary with phos. removal	O.D. #82 Stip. #00116	7/25/51 8/11/69	Compl.	Compl.	Compl.	12/1/72	
Meridian Twp. (Ingham County)	Municipal	Red Cedar River	A 2 B 2 C 3 D	Sanitary	.95	East Lansing WWTP	1970* #1583			Equivalent to secondary with phos. removal			Compl.	Compl.	Compl.	10/1/71	Improvement of force main and pumping station (served by East Lansing)

Table V-7 (Cont'd)

LOCATION	SOURCE	RECEIVING WATERS	RECEIVING Protected Uses*	TYPE OF WASTE	VOL. (mgd)	TREATMENT PROVIDED	YEAR OF GRANT REQUEST OR FED. GRANT	PRIORITIES State	PRIORITIES Basin	REQUIRED TREATMENT	ACTIONS TAKEN O.D. F.O.D. Stip. or Other	ACTIONS TAKEN Date Adopted or Revised	COMPLIANCE DATES Preli. Plans	COMPLIANCE DATES Final Plans	COMPLIANCE DATES Start Const.	COMPLIANCE DATES Proj. Compl.	REMARKS
Fowler-ville	Municipal	Red Cedar R.	A 2 B 2 C 2,3 D	Sanitary	.16	Secondary (Lagoon)				Treatment adequate							Expansion may be needed in near future
	Hoover Ball & Bearing Co. Utilex Div.	Red Cedar R.	A 2 B 2 C 2,3 D	Plating Waste	.35	Chemical Precip., Lagoons & Sludge Removal				SS < 25 ppm Oil < 15 ppm pH 6.5-8.5 Zn <.5 ppm Cu <.06 ppm Ni < 1 ppm Cr <.06 ppm	Stip. #00051	6/7/68	Compl.	Compl.	Compl.	Compl.	
Webber-ville	Municipal	Red Cedar R.	A 2 B 2 C 2,3 D	Sanitary	.10	Secondary (Lagoons)	1967* #1190			Treatment adequate	F.O.D. #1103	1/17/68	Compl.	Compl.	Compl.	Compl.	
Grant	Municipal	Crockery Creek	A 2 B 2 C 2,3 D	Sanitary	.08	Secondary plus SF					#1484	3/18/71	Compl.	Compl.	7/1/71		Lagoon planned Semi-annual discharges
Westphalia	Pewamo-Westphalia School	Unnamed creek to Maple River	A 2 B 2 C 2,3 D	Sanitary		Septic Tanks					#981 4/27/67						Seasonal discharge
Byron Center	DeBruyn Produce Company	Buck Creek	A 2 B 2 C 3 D	Wast Process	INT.	None					#385 6/22/61						
Wyoming	Road Equipment Corporation	Cole Drain to plaster	A 2 B 2 C 3 D	Oils, Washing Trailers & Tank Trucks	.008	Oil Skimmer				pH 6.5-10.5 CE < 20 mg/l Settleable solids zero	O.D.#933	10/66					

Index to Abbreviations used in Table V-7

+ *Protected Uses*

A-1 Water Supply - Domestic
A-2 Water Supply - Industrial
B-1 Recreation - Total Body Contact
B-2 Recreation - Partial Body Contact
C-1 Fish, Wildlife and Other Aquatic Life - Intolerant Fish, Coldwater Species
C-2 Fish, Wildlife and other Aquatic Life - Intolerant Fish, Warm Water Species
C-3 Fish, Wildlife and other Aquatic Life - Tolerant Fish, Warm Water Species
C-4 Fish, Wildlife and other Aquatic Life - Anadromous fish species
D Agriculture
E Commercial and Other

++ *Treatment Provided*

A. Physical

1. *Sub-classification No. 1*

   a. *Plain aeration.*
   b. *Plain clarification.*

      1) *Plain sedimentation.*
      2) *Skimming.*
      3) *Gravity separation.*
      4) *Flotation.*

   c. *Screening.*
   d. *Impoundment-regulated discharge.*

2. *Sub-classification No. 2*

   a. *Filtration.*
   b. *Radioactivity monitoring.*
   c. *Air flotation.*
   d. *Gas stripping.*
   e. *Certrifuging.*

B. Chemical.

1. *Sub-classification No. 1*

   a. *Sludge conditioning.*
   b. *Neutralization.*
   c. *Evaporation - condensation.*
   d. *Adsorption.*
   e. *Absorption.*

2. *Sub-classification No. 2.*

   a. *Clarification.*

      1) *Chemical coagulation.*
      2) *Precipitation.*
      3) *Emulsion breaking.*

   b. *Ion exchange.*

3. *Sub-classification No. 3*

   a. *Oxidation-reduction.*
      (electro plating and related wastes)

C. *Biological.*

1. *Sub-classification No. 1*

   a. *Extended aeration.*
   b. *Aerated lagoons.*
   c. *Oxidation ponds.*

2. *Sub-classification No. 2.*

   a. *Disinfection.*
   b. *Trickling filters.*
   c. *Aerobic and anerobic digestion.*

3. *Sub-classification No. 3*

   a. *Activated sludge*

* *Year of grant request or Federal grant. Communities receiving a grant for the year in which they applied were noted with an asterisk. If a 1971 grant follows a 1970 grant with an asterisk the community refiled the 1971 grant prior to receiving an offer for the 1970 grant.*

** *Required Treatment*

Treatment necessary to meet water quality standards to include phosphorus removal, will be required of all municipal treatment plants no later than 1972 in the Grand River Basin.

LOWER GRAND RIVER BASIN

MUNICIPALITIES DISCHARGING TO SURFACE WATERS IN THE GRAND RIVER BASIN

LEGEND

(2) CURRENT DISCHARGES

[2] PROPOSED DISCHARGES

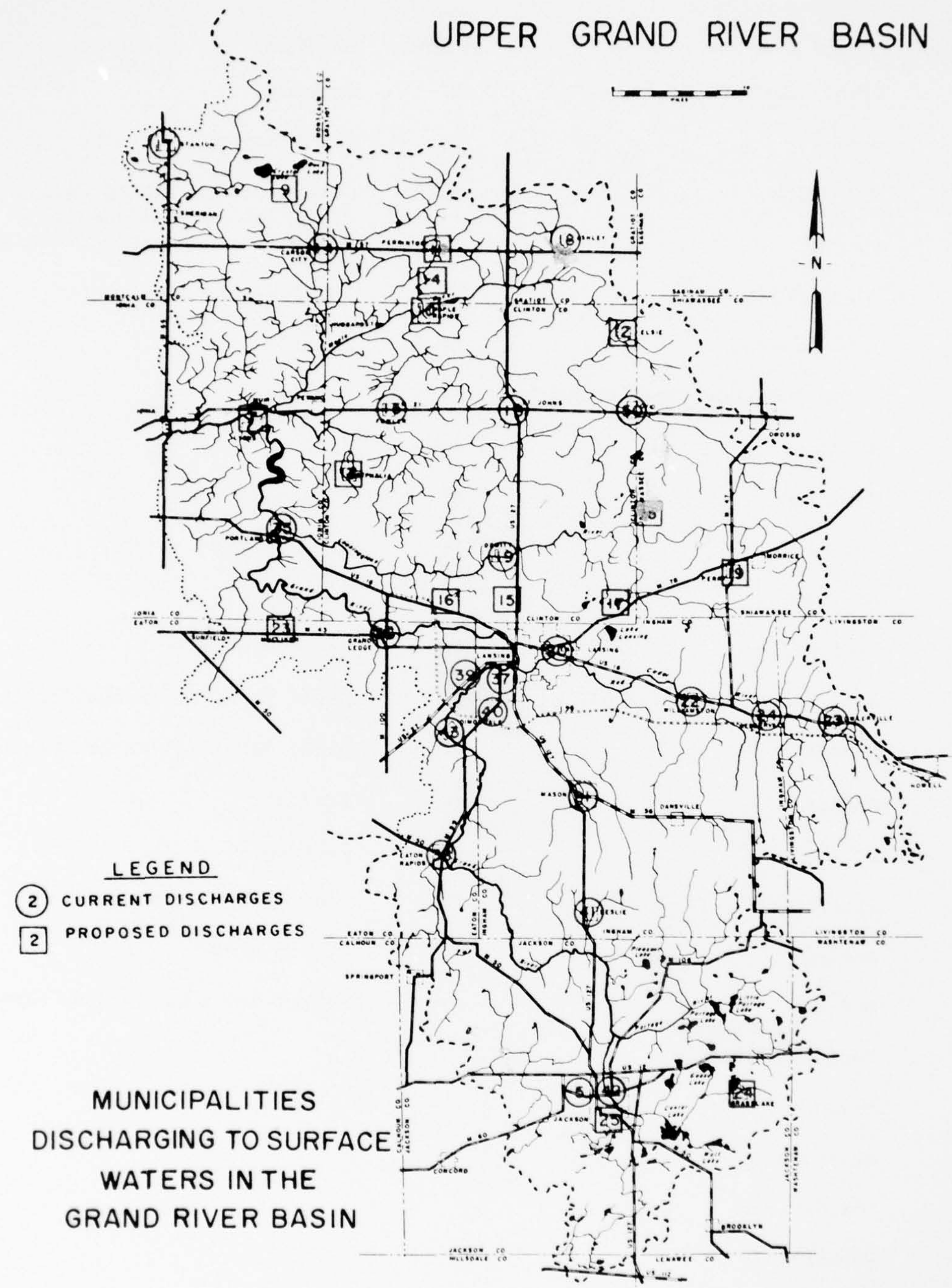

UPPER GRAND RIVER BASIN
N
LEGEND
2 CURRENT DISCHARGES
2 PROPOSED DISCHARGES
MUNICIPALITIES
DISCHARGING TO SURFACE
WATERS IN THE
GRAND RIVER BASIN

Figure 2

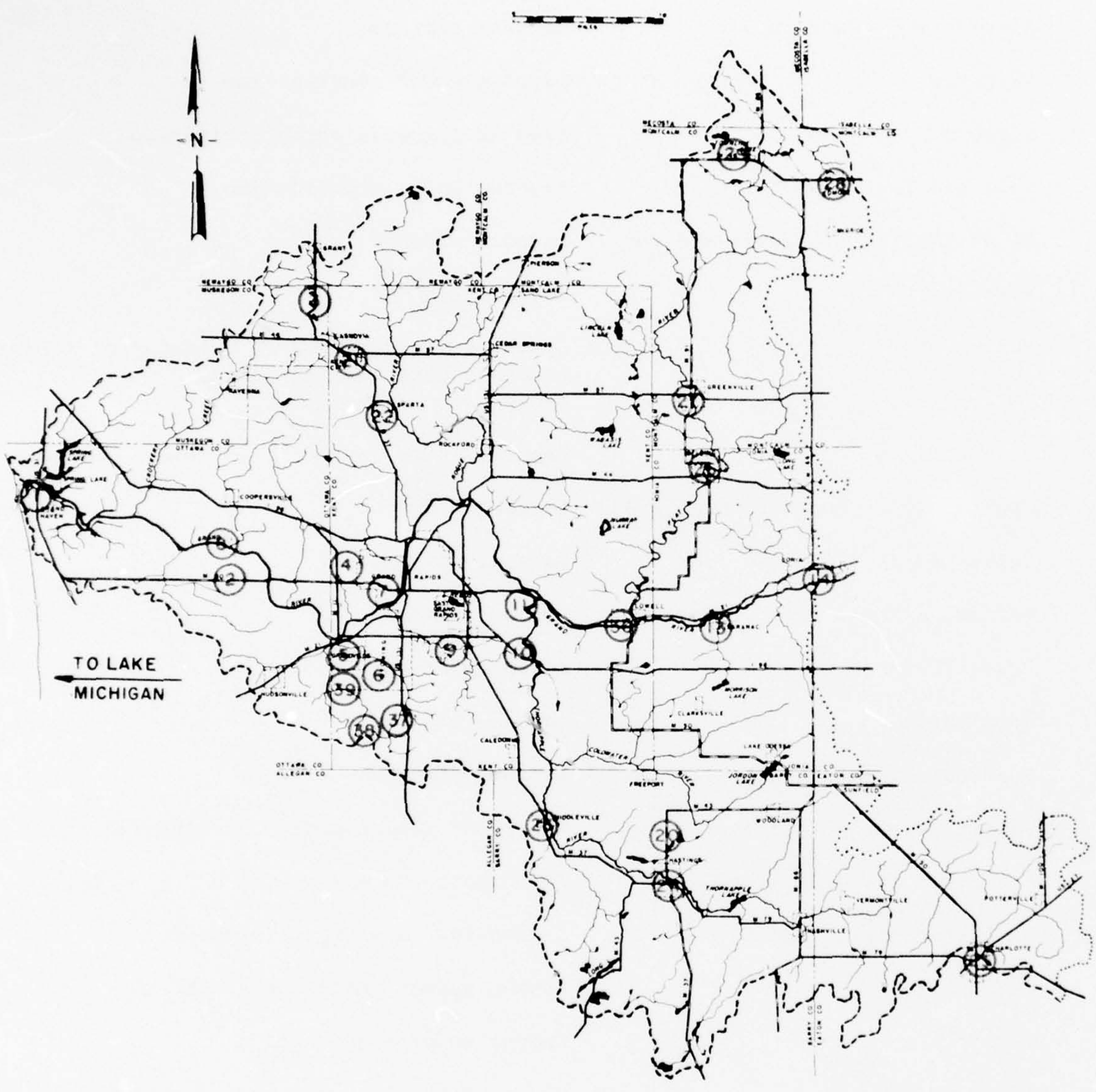
LEGEND FOR CURRENT MUNICIPAL WASTEWATER DISCHARGES

Map Number	Location	Map Number	Location
1	Grant (Newaygo County)	28	Wyoming
2	Ovid	29	Grand Rapids
3	Kent City	30	Ottawa County (Grand Valley State College, Allendale Township & Georgetown Township
4	Sparta		
5	Potterville	31	Ada Township (Kent County)
6	Lake Odessa	32	Lowell
7	Byron Township (Kent County)	33	Saranac
8	Hastings	34	Ionia
9	Woodland	35	Portland
10	Nashville	36	Grand Ledge
11	Belding	37	Lansing
12	Greenville	38	Eaton Rapids
13	Sand Lake (Kent County)	39	Delta Township (Eaton County)
14	Edmore	40	Delhi Township (Ingham County)
15	Fowler	41	Leslie
16	St. Johns	42	Jackson
17	Stanton	43	Dimondale (Eaton County)
18	Ashley	44	Carson City
19	Dewitt	45	Wright Township (Ottawa County)
20	East Lansing		
21	Mason		
22	Williamston		
23	Fowlerville		
24	Webberville		
25	Grand Haven & Spring Lake		
26	Coopersville		
27	Grandville		

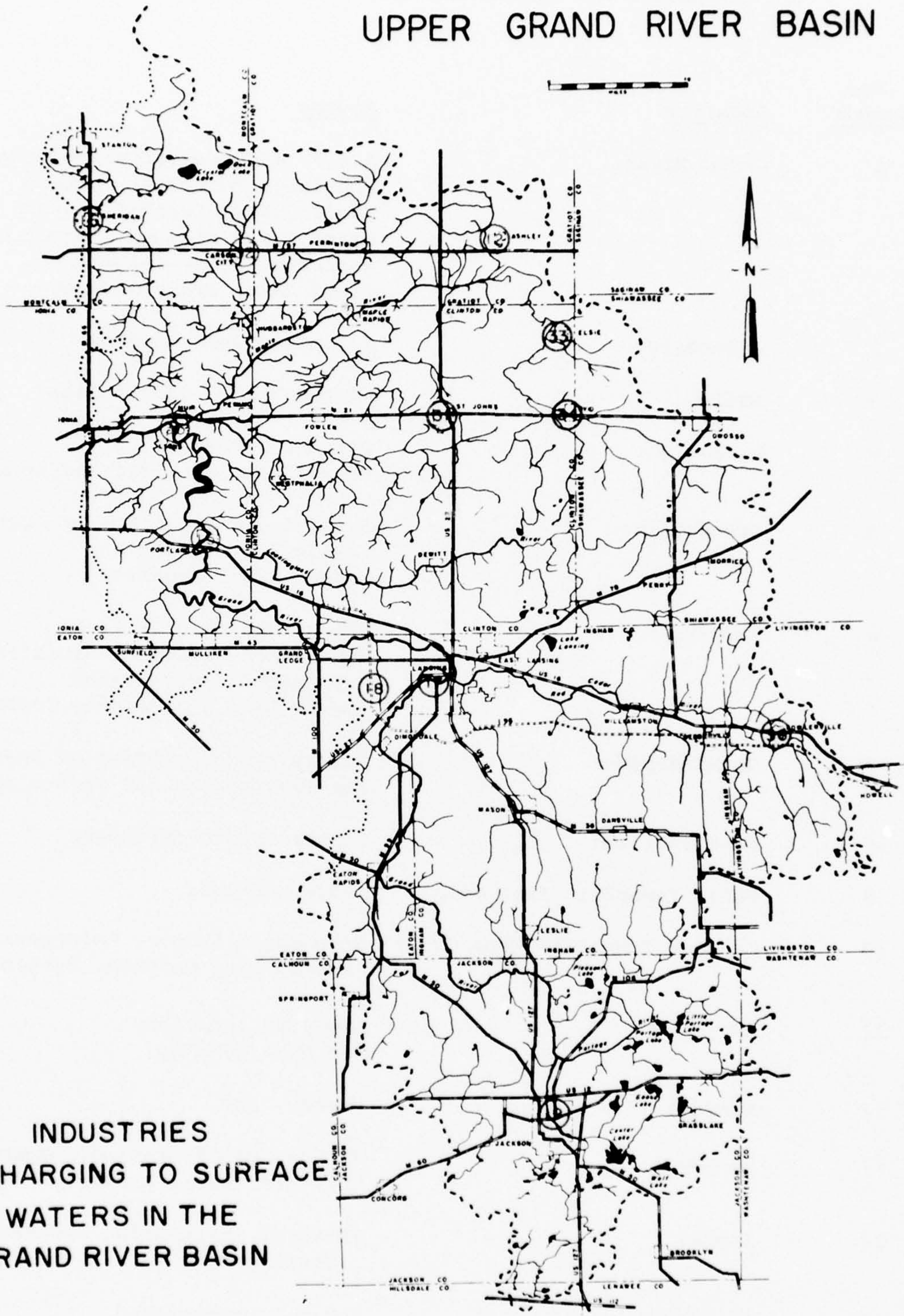
LEGEND FOR PROPOSED MUNICIPAL WASTE TREATMENT FACILITIES MAP

Map Number	Location	Status
1	Algoma Twp. (Kent Co.)	Lagoons planned
2	Casnovia	Lagoons under construction
3	Clarksville	Lagoons planned, spray irrigation
4	Sunfield Township (Eaton Co.)	Lagoons under construction
5	Bowne Twp. Imp. Dist.#1(Kent Co.)	Lagoons planned
6	McBride	Lagoons planned
7	Muir-Lyons	Lyons is constructing an interceptor to Muir which is constructing a lagoon system to serve both communities
8	Vermontville	Lagoons under construction, spray irrigation
9	Crystal Twp. (Montcalm Co.Dist#1)	Lagoons planned
10	Maple Rapids	Lagoons planned
11	Perrinton Municipal (Gratiot Co.)	Lagoons planned
12	Elsie (Clinton Co.)	Lagoon planned
13	Westphalia	Lagoons planned
14	Fulton Twp. (Gratiot Co.)	Lagoons planned
15	Dewitt Township (Clinton Co.)	Activated sludge under construction
16	Watertown Twp. (Clinton Co.)	Interceptor to the Dewitt S.T.P. planned
17	Bath Township (Clinton Co.)	Lagoon and interceptor planned
18	Laingsburg	Lagoon system under construction
19	Perry	Lagoon under construction
20	Kentwood	Pinnebrook interceptor to Wyoming S.T.P.
21	Gaines Township,Dutton (Kent Co.)	Interceptor to Wyoming S.T.P.
22	Cannon Township (Kent Co.)	Interceptor to Grand Rapids S.T.P.
23	Mulliken	Lagoon under construction
24	Grass Lake (Jackson County)	Lagoons planned
25	Jackson Metropolitan	Black & Summit Twps. plan an interceptor to Jackson S.T.P. Spring Arbor & Leoni Twps. each plan lagoon & spray irrigation systems
26	Caledonia	Lagoons planned, spray irrigation

LOWER GRAND RIVER BASIN



INDUSTRIES DISCHARGING
TO SURFACE WATERS IN
THE GRAND RIVER BASIN



INDUSTRIES
DISCHARGING TO SURFACE
WATERS IN THE
GRAND RIVER BASIN

Figure 3

LEGEND FOR INDUSTRIAL WASTE DISCHARGE MAP

Map Number	*Location*	*Source*
1	Grand Haven:	A.S.P. and Manufacturing Company Challenge Porcelain Company Eagle Ottawa Leather Company Grand Haven Stamped Product Company Municipal Power Company Grand Haven Brass Company
2	Allendale:	Allendale Beef Company
3	Bailey:	Vintage Foods Incorporated
4	Walker:	Bissell Incorporated Bissell Incorporated-Indian Mill Creek
5	Grandville:	Packaging Corporation of America Jervis Corporation Nelson Metal Products
6	Wyoming:	Chesapeake-Ohio RR Yards GMC Diesel Equipment Division Kelvinator Incorporated Hoover Ball and Bearing Company
7	Grand Rapids:	Packaging Corporation of America Jet Electronics and Technology, Inc.
8	Eastmanville:	Ottawa County Infirmary
9	Paris Township (Kent Co.):	Kroger Company
10	Cascade Township (Kent Co.):	Stephenson Lawyer, Incorporated Cascade Data Computer Systems
11	Ada:	Amway Corporation Ada Beef Company
12	Ashley:	Portec, Inc.
13	Saranac:	Saranac Manufacturing Company Universal Metal Products
14	Ionia:	Integral Engineering and Manufacturing Corporation
15	Portland:	T.R.W. Incorporated

Map Number	Location	Source
16	Sheridan:	Carnation Milk Company
17	Lansing:	G.M.C. Oldsmobile Forge Division G.M.C. Oldsmobile Division #3 Board of Water and Light Otto E. Eckert Power Station John Bean Corporation
18	Delta Township (Eaton Co.):	G.M.C. Parts Division
19	Jackson:	Clark Equipment Company LaFere Forge and Machine Company Penn Central Railroad Goodyear Tire and Rubber Company Pittsburgh Forging Company Richardson Asphalt Company Dyecast Corporation
20	Barry County:	Barry County Medical Facilities
21	Kent City:	National Fruit Products Company, Incorporated
22	Sparta:	Sparta Foundry Company
23	Middleville:	Bradford White Products Corporation
24	Hastings:	Hastings Aluminum Products, Incorporated Hastings Manufacturing Company (2 outfalls) E. W. Bliss Company
25	Charlotte:	Allen Packing Company Owens-Illinois Glass Company
26	Belding:	Extruded Metals Company Gibson Products Division, White Consolidated Industries Indian Summer Incorporated
27	Greenville:	Federal Mogul Corporation Gibson Products Division White Consolidated Industries Ore-Ida Foods, Incorporated Ranney Refrigeration Company Greenville Fetters Corporation
28	Edmore:	Aunt Jane's Foods, Division of Bordens Company
29	Six Lakes:	Michigan Consolidated Gas Company
30	Lowell:	Attwood Corporation

Map Number	Location	Source
31	St. Johns:	Federal Mogul Corporation
32	Carson City:	Crystal Refinery Company Vlasic Foods Incorporated
33	Elsie (Clinton County):	Hancock Industries, Incorporated
34	Ovid:	Michigan Milk Producers Association
35	Lyons:	Chrysler Corporation Trims Plant
36	Fowlerville:	Hoover Ball and Bearing Company, Utilex Division
37	Kent County:	Kent County Airport
38	Byron Center (Kent Co.):	De Bruyn Company
39	Wyoming	Road Equipment Company

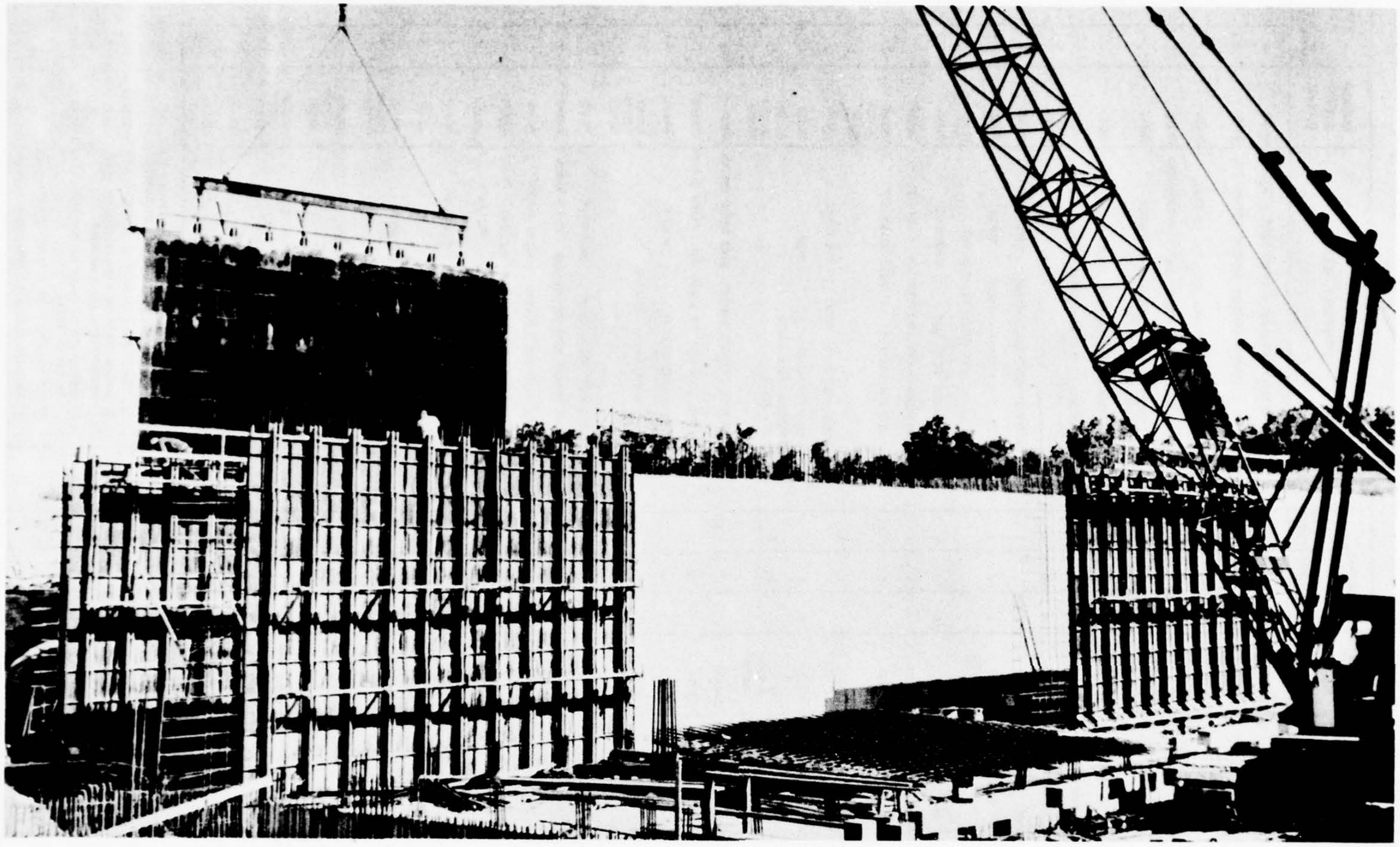


Figure V-4. A photograph of the sewage treatment facility addition under construction at East Lansing. The East Lansing plant is one of several in the basin to be expanded or modified to provide improved treatment processes.

Table V-8 INDUSTRIAL WASTEWATER CONTROL STATUS-1972

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	ANNUAL RATING 1971	ANNUAL RATING 1972
A.S.P. MANUFACTURING CO. GRAND HAVEN	GRAND	A	A	A
ADA BEEF COMPANY ADA	GRAND GROUND WATER	A	A	A
ADAMS TOOL & ENGINEERING, INC. LANSING	GRAND			A
ADHESIVES DEVEL. & CHEMICAL CO. MICHIGAN CENTER	GRAND			B
AEROQUIP CORP-ELBEECO PLANT AIRCRAFT DIVISION - JACKSON	GRAND			A
ALBERT SAND & GRAVEL, INC. FOWLERVILLE	GRAND		B	A
ALLENDALE PACKING COMPANY ALLENDALE	GRAND	A	A	A
ALLOYED GRAIRON CASTINGS CORP. RAVENNA	GRAND			A
AMERICAN ANDDCO CORPORATION IONIA	GRAND GROUND WATER	A	A	A
AMWAY CORPORATION ADA	GRAND	D	E	I 1/
ATCO RUBBER PRODUCTS GRAND HAVEN	GRAND		B	A
ATTWOOD CORPORATION LOWELL 18" PLATING WASTE TO FLAT RIVER	GRAND		B	I 2/
ATTWOOD CORPORATION LOWELL 14" COOLING WATER TO FLAT RIVER	GRAND		B	A
AUNT JANE FOODS, DIV. BORDEN INC. EDMORE	GRAND	B	A	A
BELDING FRUIT STORAGE INC.-BELDING	GRAND GROUND WATER	A	A	A
BENDIX CORPORATION, JACKSON ABRASIVES DIV.	GRAND			I 3/
BISSELL INCORPORATED WALKER	GRAND		A	A
BLISS, E.W. HASTINGS	GRAND	D	A	A
BONTERS SLAUGHTERHOUSE BAILEY	GRAND GROUND WATER		B	A
BRANDFORD WHITE CORP. WHITE PRODUCTS DIV. MIDDLEVILLE	GRAND	D	D	I 4/
BROWN CORP. OF IONIA INC. IONIA	GRAND GROUND WATER			A
BUGGS BROTHERS LOCKERS ST. JOHNS	GRAND GROUND WATER	A	A	A
C & A LAUNDROMAT BANCROFT FORMERLY BAYER, M. & J.	GRAND GROUND WATER	A	A	A
CALEDONIA PACKING CO. CALEDONIA	GRAND		B	A
CAMSHAFT MACHINE CO JACKSON	GRAND GROUND WATER			B
CARNATION MILK COMPANY SHERIDAN	GRAND	A	A	B
CARSON CITY LOCKERS CARSON CITY	GRAND		B	A
CHALLENGE STAMPING & PORCELAIN CO. GRAND HAVEN	GRAND	B	A	A
CHEM-TREND INC. HOWELL	GRAND GROUND WATER	B	A	A
CHERRY HILL ORCHARDS BAILEY	GRAND GROUND WATER		A	A

1/ CITY SANITARY SEWER CONNECTION UNDER CONST.

2/ PLANS TO UPGRADE TREATMENT BEING PREPARED.

3/ ACTION AWAITING FINALIZATION OF NPDES PERMIT EFFLUENT RESTRICTIONS AND TIMETABLE.

4/ PLANS UNDERWAY TO UPGRADE FACILITY

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	ANNUAL RATING 1971	ANNUAL RATING 1972
CHRYSLER CORPORATION - LYONS TRIM LYONS	GRAND	A	A	A
CLARK EQUIPMENT COMPANY JACKSON AUTOMOTIVE DIV.	GRAND	A	A	A
CONSOLIDATED ALUMINUM CORP. JACKSON	GRAND			A
CONSTRUCTION AGGREGATES CORP. FERRYSBURG	GRAND			A
CONSUMERS POWER COMPANY-GRAND RAPIDS-WEALTHY STREET PLANT	GRAND		A	A
CORDUROY RUBBER COMPANY GRAND RAPIDS	GRAND			A
COTHRAN, J. D., CO. GRASS LAKE, SUB. EXCEL CORP.	GRAND GROUND WATER			B
CRYSTAL REFINING COMPANY CARSON CITY	GRAND	B	B	I 1/
CULLIGAN SALES & SERVICE IONIA	GRAND		B	A
CULLIGAN SOFT WATER PLT-HASTINGS	GRAND			I 2/
CULLIGAN WATER COND. GREENVILLE	GRAND		B	A
CULLIGAN WATER CONDITIONING DEWITT	GRAND			A
DAKE CORPORATION GRAND HAVEN	GRAND GROUND WATER		B	A
DANS PROCESSING PLANT SIX LAKES	GRAND		B	A
DART CONTAINERS CORP. MASON	GRAND		B	I 3/
DEBOER, MARK & SON ST. JOHNS	GRAND GROUND WATER		B	A
DEBRUYN PRODUCE COMPANY NEAR BYRON CENTER	GRAND	A	A	A
DEXTER LOCK-DIV. OF KYSOR IND. GRAND RAPIDS	GRAND			B
DIECAST CORPORATION JACKSON	GRAND	A	A	A
DUFFY-MOTT CORP. BAILEY	GRAND GROUND WATER	A	A	A
DULLS MEAT PROC. PLANT NASHVILLE	GRAND		B	A
EAGLE OTTAWA LEATHER COMPANY GRAND HAVEN	GRAND	E	E	I 4/
EATON STAMPING COMPANY EATON RAPIDS	GRAND			A
FARM MEAT PACKING, INC. JACKSON	GRAND		B	B
FEDDERS CORP.- RANNEY REFRIG. DIVISION GREENVILLE	GRAND	E	E	I 5/
FEDERAL MOGUL DIVISION GREENVILLE	GRAND	A	B	A
FEDERAL MOGUL- ST. JOHN	GRAND	E	E	I*
FENSKE, HOWARD - GRAND RAPIDS WASTE HAULING DISPOSAL SITE	GRAND GROUND WATER			A
FINK, R.N. MANUFACTURING CO. INC. WILLIAMSTON	GRAND GROUND WATER			B
FULLER, CLARENCE - ADA WASTE HAULING DISPOSAL SITE	GRAND GROUND WATER			A
GARDNER-DENVER COMPANY GRAND HAVEN	GRAND		A	A
GEMMEN, A. & SONS ALLENDALE	GRAND		B	A

1/ PROGRAM REVIEWED WITH COMMISSION APRIL 1973. REPORT ON SPECIFIC ACTION PLAN WILL BE SUBMITTED.

2/ WILL CONNECT TO CITY OF HASTINGS SANITARY SEWER.

3/ ACTION AWAITING FINALIZATION OF NPDES PERMIT EFFLUENT RESTRICTIONS AND TIMETABLE.

4/ CONNECTION TO GRAND HAVEN-SPRING LAKE SYSTEM TO BE COMPLETED BY END OF 1973.

5/ NEW TREATMENT FACILITIES 80% COMPLETE.

6/ FACILITY COMPLETED; PERFORMANCE BEING REVIEWED.

Annual Rating:
A = Control Adequate
B = Control Provided - adequacy not fully established.
"C"= Water Resources Commission has discontinued use of "C" rating.
D = Control Provided - unreliable.
E = Control inadequate.

Table V-8 (Continued) INDUSTRIAL WASTEWATER CONTROL STATUS - 1972

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	ANNUAL RATING 1971	ANNUAL RATING 1972
GENERAL MOTORS CORP. PARTS DIV.-DELTA TWP.	GRAND		A	A
GENERAL MOTORS CORP.-GRAND RAPIDS FISHER BODY PLANT NO 2	GRAND		B	A
GENERAL MOTORS CORP.-LANSING OLDSMOBILE PLANT #2	GRAND		B	A
GENERAL MOTORS CORP. DIESEL EQUIPMENT DIV. WYOMING	GRAND	A	A	A
GENERAL PRODUCTS CORPORATION JACKSON	GRAND GROUND WATER			A
GEORGES SLAUGHTERHOUSE SARANAC	GRAND		B	A
GEUKES MKT. MIDDLEVILLE	GRAND GROUND WATER		E	A
GOODYEAR TIRE & RUBBER CO. JACKSON	GRAND		B	B
GRAND HAVEN STAMPED PRODUCTS CO. GRAND HAVEN	GRAND	A	A	A
GRAND TRUNK WESTERN R. R. - MILLETT DELTA TWP., EATON CO.	GRAND GROUND WATER		A	A
HANCOCK INDUSTRIES, INC. ELSIE	GRAND GROUND WATER	B	B	B
HENNAS SLAUGHTERHOUSE SUNFIELD	GRAND GROUND WATER		B	A
[illegible] INDUSTRIES, INC. GRAND HAVEN	GRAND GROUND WATER		B	A
HASTINGS ALUMINUM PRODUCTS INC. HASTINGS	GRAND	D	A	A
HASTINGS CORP HASTINGS	GRAND			B
HASTINGS MANUFACTURING COMPANY HASTINGS	GRAND	A	A	A
HEIFTIZ PICKLING COMPANY EATON RAPIDS	GRAND			A
HOOVER BALL & BEAR CO. UTILEX DIV. FOWLERVILLE	GRAND	B	B	B
HOUGHTON BEEF PACKERS IONIA	GRAND GROUND WATER		B	A
HUEBNER, F.M. CO. JACKSON	GRAND			A
HUIZENGA WHSE, MEATS JENISON	GRAND GROUND WATER		A	A
INDIAN HEAD COMPANY EXTRUDED METAL DIVISION-BELDING	GRAND	B	B	B
INDIAN SUMMER, INC.- BELDING	GRAND	A	*	A
INDUSTRIAL PAINTING ST. JOHNS	GRAND GROUND WATER	B	B	A
INMONT CORP. GRAND RAPIDS AUTOMOTIVE GROUP	GRAND GROUND WATER			A
INTEGRAL ENGINEERING & MFG. CORP. IONIA	GRAND GROUND WATER	B	B	A
JACKSON IRON & METAL JACKSON	GRAND			A
JERVIS CORPORATION-GRANDVILLE	GRAND	A	A	I 1/
JEWELL, CHARLES, MEATS COOPERVILLE	GRAND		B	A

1/ACTION AWAITING FINALIZATION OF NPDES PERMIT EFFLUENT RESTRICTIONS AND TIMETABLE

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	ANNUAL RATING 1971	ANNUAL RATING 1972
JOHN BEAN CORPORATION - LANSING DIVISION OF FMC CORP.	GRAND	B	[illegible]	[illegible] 1/
KELVINATOR, INC.-WYOMING	GRAND	[illegible]	A	[illegible]
KIBBY COBB MART JACKSON	GRAND GROUND WATER		[illegible]	A
KIRKHOF MANUFACTURING CORP. GRAND RAPIDS	GRAND			[illegible]
KNAPE INDUSTRIES INC. ROCKFORD	GRAND GROUND WATER	A	[illegible]	[illegible]
LABADIE, W.C., MACHINE SHOP GRASS LAKE	GRAND GROUND WATER		[illegible]	[illegible]
LAKE ODESSA CANNING CO. LAKE ODESSA	GRAND		[illegible]	[illegible]
LANSING BOARD OF WATER & LIGHT OTTO E. ECKERT POWER STATION	GRAND	[illegible]	[illegible]	[illegible] 2/
LANSING BOARD OF WATER & LIGHT OTTAWA ST. STATION-LANSING	GRAND		A	[illegible]
LANSING BOARD OF WATER & LIGHT ERICKSON STATION-DELTA TWP.	GRAND			B
LEIGH PRODUCTS INC. COOPERSVILLE	GRAND GROUND WATER		[illegible]	[illegible]
LIBERMAN & GITTLEN METAL CO., INC. GRAND RAPIDS	GRAND		B	A
LINDELL DROP FORGE LANSING	GRAND			A
LU VAN, INC. BELDING	GRAND		B	A
LUNDBERG MFG. CO., INC. JACKSON	GRAND		B	A
MAHOGANY FARMS, INC., WILLIAMSTON MEAT PROCESSING & PACKAGING	GRAND GROUND WATER			A
MARI WAY FARM-NASHVILLE	GRAND			B
MCDONALDS FARR VIEW DAIRY FRUITPORT	GRAND GROUND WATER	B	B	A
MICHIGAN CONSOLIDATED GAS CO. SIX LAKES	GRAND	A	A	A
MICHIGAN MILK PROD. ASSOC.-OVID	GRAND GROUND WATER	A	A	A
MICHIGAN MILK PRODUCERS DAIRY LOWELL	GRAND GROUND WATER		B	A
MICHIGAN PROD GRINDING CO. CLARKLAKE	GRAND GROUND WATER			B
MIDLAND-ROSS CORP. GRANDVILLE-NELSON METAL PROD. DIV.	GRAND	A	A	B
MILLER DAIRY FARMS, INC. EATON RAPIDS	GRAND			I 3/
MILLIGAN PKG. CO. PARMA	GRAND GROUND WATER		B	B
MODERN CONCRETE PRODUCTS GRAND RAPIDS	GRAND			B
MUSKEGON PISTON RING CO. SPARTA	GRAND	B	A	A
MYAARDS MEATS HUDSONVILLE	GRAND GROUND WATER		A	A

1/ ACCIDENT PREVENTION MEASURES HAVE BEEN TAKEN.

2/ CONSTRUCTION TO BE COMPLETED DECEMBER 31, 1973.

3/ PROBLEM HAS BEEN CORRECTED.

e. Absorption.

Table V-8 (Continued) INDUSTRIAL WASTEWATER CONTROL STATUS-1972

INDUSTRIAL WASTEWATER CONTROL STATUS-1972

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	1971	1972
NATIONAL FRUIT PRODUCTS CO., INC. KENT CITY	GRAND	A	A	A
NORTHEAST GRAVEL COMPANY - BELMONT WASTE HAULING DISPOSAL SITE	GRAND GROUND WATER		B	A
OLDBURG MANUFACTURING COMPANY GRAND HAVEN	GRAND	A	A	A
ORE-IDA FOODS INC. -GREENVILLE	GRAND GROUND WATER	A	A	A
OWENS-ILLINOIS GLASS COMPANY CHARLOTTE	GRAND	E	A	A
PACKAGING CORP. OF AMERICA AMER. BOX BOARD DIV.-GRANDVILLE	GRAND	A	A	A
PENDELLS MEAT PROC. CARSON CITY	GRAND GROUND WATER		B	A
PENN CENTRAL RAILROAD JACKSON	GRAND	B	B	B
PEPSI COLA METRO BOTTLING CO. WYOMING	GRAND			B
PITTSBURGH FORGINGS CO. JACKSON	GRAND	D	B	B
PRYOR BROS. SAND & GRAVEL GRAND LEDGE	GRAND			A
REM DIE CASTING CO. GRAND RAPIDS	GRAND GROUND WATER	B	B	I 1/
REM DIE CASTING, INC. - SARANAC	GRAND GROUND WATER	B	D	I 2/
RICHARDSON ASPHALT CORP. JACKSON	GRAND	D	A	A
ROCKFORD PAPER MILLS, INC. ROCKFORD	GRAND GROUND WATER	A	A	A
SAGES SLHSE. GREENVILLE	GRAND GROUND WATER		A	A
SEALED POWER CORP. ST. JOHNS	GRAND		B	A
SIBLE PACKING CO. LAKE ODESSA	GRAND		D	I 3/
SMALLEGANS WHSE. MEATS HUDSONVILLE	GRAND GROUND WATER		A	A
SMITH BROS. FERTILIZER PLANT WOODBURY	GRAND GROUND WATER			I 4/
SPARTAN ASPHALT PAVING CO. HOLT	GRAND GROUND WATER			B
SWANSON PICKLE COMPANY RAVENNA	GRAND GROUND WATER	A	A	A
TEXTRON, INC.-HOWELL CLEVELAND METAL ABRASIVES	GRAND		B	A
THORREZ C. INDUSTRIES JACKSON	GRAND			A
TMC INDUSTRIES INC. BELDING	GRAND			A

1/ ACTION AWAITING FINALIZATION OF NPDES PERMIT EFFLUENT RESTRICTIONS AND TIMETABLE.

2/ PLANS CONDITIONALLY APPROVED APRIL 1973, PENDING MINOR CHANGES.

3/ IN-PLANT IMPROVEMENTS BEING MADE.

4/ PLANS APPROVED. FACILITY TO BE READY BY JULY 15, 1973.

INDUSTRIAL WASTEWATER CONTROL STATUS-1972

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING 1970	1971	1972
TRW INCORPORATED PORTLAND	GRAND GROUND WATER	D	D	A
UNIVERSAL METAL PRODUCTS-SARANAC	GRAND	A	A	A
VANALSTINES SLAUGHTERHOUSE EAST LANSING	GRAND GROUND WATER		B	A
VINTAGE FOODS BAILEY	GRAND	E	E	B
VLASIC FOOD PRODUCTS CO. CARSON CITY	GRAND	[illegible]	E	I 1/
WALKER MFG. CO.- JACKSON MICH. DIVISION, PLANT I	GRAND	B	*	A
WELDED PRODUCTS INC - GRAND HAVEN DIV OF TECHNOLOGY INC.	GRAND			B
WESTERN STAMPING CORP. JACKSON	GRAND GROUND WATER			B
WHITE CONSOLIDATED IND. BELDING GIBSON PRODUCTS CORP.	GRAND	D	E	[illegible]
WHITE CONSOLIDATED IND. GREENVILLE GIBSON REFRIGERATOR DIV.	GRAND	E	[illegible]	I
WILLIAMS SLAUGHTERHOUSE ASHLEY	GRAND GROUND WATER		B	A
WOLVERINE METAL SPECIALTIES INC. JACKSON	GRAND GROUND WATER			B
WRIGHTS SLAUGHTERHOUSE IONIA	GRAND GROUND WATER		B	A
WYETH LABORATORIES, INC. - MASON DIV. AMERICAN HOME PRO. CO.	GRAND		B	A
ZANDBERGENS MEATS GRANDVILLE	GRAND GROUND WATER		A	A
4-D CORPORATION LANSING	GRAND GROUND WATER	B	A	A

1/ LAGOON CONSTRUCTION COMPLETED. FACILITY NOW OPERATIONAL.

2/ IN-PLANT CHANGES BEING MADE. PLANS FOR NEW TREATMENT FACILITY BEING PREPARED.

Table V-9

COMMERCIAL WASTEWATER CONTROL STATUS- 1972

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING		
		1970	1971	1972
AIKEN, R. AND BURNS G. AUTOMATIC LAUNDRY, JACKSON	GRAND GROUND WATER	B	B	A
BAKER, EDWARD, COIN-OP LAUNDRY NEAR JACKSON	GRAND GROUND WATER		A	A
BAUER, JOSEPH A. LAUNDROMAT VANDERCOOK LAKE	GRAND GROUND WATER		A	A
BENTLY, PAUL JACKSON AUTO. LAUNDRY	GRAND GROUND WATER	A	A	A
CANDLESTONE, INC MOTEL & REST. NEAR BELDING	GRAND GROUND WATER			A
CASCADE DATA COMPUTER SYSTEMS GRAND RAPIDS	GRAND	A	A	A
CHARVER CORP. RESTAURANT I-96 & 48th ST., WRIGHT TWP.	GRAND GROUND WATER		B	I 1/
COOKS SOFT WATER SERVICE ELSIE	GRAND		B	A
DELTON-KELLOGG SCHOOL DELTON	GRAND		A	A
EDMONDS, DAVE C., CAR WASH MUIR	GRAND GROUND WATER		A	A
GRASS LK. LAUND. CORP-GRASS LAKE	GRAND GROUND WATER		A	A
GREEN, MERLE FARM ELSIE	GRAND GROUND WATER	[illegible]	A	A
HARRINGTON, LAWRENCE & TREVA AUTO LAUNDRY JACKSON	GRAND GROUND WATER	B	B	A
HAUSCH PKG. CO. EATON RAPIDS	GRAND GROUND WATER		B	A
HERMAN, P. L. AUTO. LAUNDRY RAVENNA	GRAND GROUND WATER	A	A	I 2/
HORNES OF MICHIGAN RESTAURANT IONIA	GRAND GROUND WATER	A	A	A
ISAAC, DONALD E. CAR WASH MICHIGAN CENTER	GRAND GROUND WATER	A	A	B
JACKSON COMMUNITY COLLEGE NEAR JACKSON	GRAND GROUND WATER		B	A
JET ELECTRONICS & TECHNOLOGY INC. GRAND RAPIDS	GRAND	A	A	A
KENOWA HILLS PUBLIC SCHOOLS JUNIOR HIGH	GRAND GROUND WATER		B	B
KENOWA HILLS PUBLIC SCHOOLS, NORTHEAST ELEM. SCH., ALPINE TWP.	GRAND GROUND WATER		B	A
KENT CO. BD. OF AERONAUTICS CASCADE TWP.	GRAND GROUND WATER		B	A
KINGSBROOKE, INC., HOUSING DEVEL. BLACKMAN TWP., JACKSON CO.	GRAND GROUND WATER	B	A	A
LAKEWOOD HIGH SCHOOL NEAR LAKE ODESSA	GRAND GROUND WATER		A	I 3/
LASALLE R. AUTOMATIC LAUNDRY CRYSTAL	GRAND	E	B	B
LIVINGSTON COUNTY LUMBER FOWLERVILLE APARTMENT DEVELP.	GRAND GROUND WATER			A

1/ REQUEST FOR SEMI-ANNUAL DISCHARGE TO DEER CREEK BEING REVIEWED.
2/ WILL BE REQUIRED TO CONNECT TO SANITARY SEWER.
3/ WILL RETAIN CONSULTANT TO PLAN LAGOON EXPANSION.

COMPANY NAME	MAJOR RIVER BASIN	ANNUAL RATING		
		1970	1971	1972
LOVELAND D. & E. CAR WASH GRASS LAKE	GRAND GROUND WATER	[illegible]	A	A
LOWELL AREA SCHOOLS, ALTO ELEM. SCHOOL AT ALTO	GRAND GROUND WATER		A	A
MICHIGAN BEEF CO. DEWITT	GRAND GROUND WATER		A	A
MILLER, J.N. EASTGATE LAUNDROMAT JACKSON	GRAND GROUND WATER	A	A	A
MILLER, J.N. COIN OP LAUNDRY VANDERCOOK LAKE	GRAND GROUND WATER		A	A
MILLISOR, DONALD DBA DON'S RESTAURANT, NEAR DIMONDALE	GRAND			I 1/
MITCHELL, J.A. AUTO. LAUNDRY JACKSON	GRAND GROUND WATER	[illegible]		[illegible]
NICHOLS, R. LAUNDRY LEONI TWP. (FORMERLY BLACK & NICHOLS)	GRAND GROUND WATER		A	A
NORTHWEST MARKET JACKSON	GRAND GROUND WATER		B	A
NORTHWEST SCHOOL DISTRICT SCHOOL - JACKSON	GRAND GROUND WATER	[illegible]	A	A
OLDS PLAZA HOTEL, LANSING	GRAND GROUND WATER			A
OLSEN, R.N. CAR WASH HASTINGS	GRAND GROUND WATER	A	A	A
OTTAWA CO. BD. OF SUPERVISORS, COUNTY INFIRMARY NEAR EASTMANVILLE	GRAND GROUND WATER		A	A
OTTAWA CO., GRAND VALLEY STATE COLLEGE	GRAND GROUND WATER		A	A
OTTAWA COUNTY SCHOOL DISTRICT ELEM. SCHOOL, NEAR CONKLIN	GRAND GROUND WATER		A	A
PLAINFIELD TOWNSHIP WATER TREATMENT PLANT	GRAND GROUND WATER		A	A
PLEASANT LAKE SERVICE CENTER PLEASANT LAKE	GRAND GROUND WATER	A	A	A
POUR HOUSE RESTAURANT DIMONDALE	GRAND GROUND WATER			I 1/
ROCKFORD PUBLIC SCHOOL SYSTEM ELEMENTARY SCHOOL ROCKFORD	GRAND GROUND WATER		A	A
ROTH, L.P., GAS INC. CAR WASH LOWELL	GRAND GROUND WATER	A	A	A
SILLS, C. HUBERT, LAUNDRY ELSIE	GRAND GROUND WATER			B
TRINITY LUTHERAN CHURCH ELEM. SCHOOL NEAR JACKSON	GRAND GROUND WATER		B	A

1/ ORDERED TO BEGIN CONSTRUCTION OF NEW TREATMENT FACILITY.

2/ NEW SYSTEM COMPLETED AND OPERATIONAL PERFORMANCE BEING EVALUATED.

Table V-10

SEWAGE DISPOSAL PRACTICES FOR HOMES IN PLACES OF LESS THAN 50,000 POPULATION, 1960*

(Data are from 1960 Census of Housing, Vol. 1, Part 5, Michigan Tables 20, 23, 25, 31, 33 and 35)

A. By County

	Total homes in places of less than 50,000	No. of these homes using public systems	Percent using public sewers	No. of these homes using septic systems	Percent using septic systems	No. of these homes with other or no disposal system	Percent with other or no disposal system
Counties with a respresentative significant portion in basin							
Barry	12,723	2,845	22	8,160	64	1,718	14
Clinton	11,178	2,056	18	7,929	71	1,193	11
Eaton	15,780	5,351	34	8,767	56	1,662	11
Gratiot	11,584	4,436	38	5,701	49	1,447	12
Ingham	28,635	12,233	43	14,543	51	1,859	6
Ionia	13,054	5,233	40	6,191	47	1,630	12
Jackson	24,311	489	2	21,790	90	2,032	8
Kent	54,082	13,759	25	38,292	71	2,031	4
Montcalm	17,660	3,191	18	11,603	66	2,866	16
Muskegon	46,430	25,385	55	19,481	42	1,564	3
Ottawa	30,766	11,198	36	18,470	60	1,098	4
Shiawassee	16,805	7,566	45	7,875	47	1,364	8
Twelve-county totals	283,008	93,742	33	168,802	60	20,464	7

Dredging and Spoil Disposal

Navigation is an important part of the economy of the Grand Haven area. Seventeen miles of channel are maintained for commercial navigation in the Grand River from Grand Haven upstream which requires annual dredging by the U. S. Corps of Engineers. Act 291, P.A. of 1965, regulates the placing of dredging spoil on bottomlands of the State. Also, the Water Resources Commission has rules that although water quality standards shall not apply during periods of authorized dredging for navigational purposes, the standards do apply in areas utilized for the disposal of spoil.

Two disposal sites are tentatively available for dredge spoil. One of the sites is on the north bank of the river and is private property. This site has been offered for disposal purposes free of charge to the Corps of Engineers. The site would handle spoil for a period of three to four years. The second proposed site is Harbor Island which lies between the south and main branches of the Grand River, downstream from the Cheasapeake and Ohio Railroad bridge. This site will provide sufficient disposal area for 12 to 15 years of dredging. A further advantage to using this site is the recreational value which would be created by filling in the low lying island. The island site would be provided at no cost by the City.

The island site has been chosen by the City of Grand Haven as the disposal site and the site has been approved by the Water Resources Commission contingent upon the use of the site for recreational purposes.

Use of the site is contingent on strict adherence to certain operational techniques and maintenance. The planned program is sufficient to maintain water quality standards in the Grand River.

Corps of Engineers acceptance of this site and Environmental Protection Agency approval of the plan will mean that no costs will occur to the City of Grand Haven for dredge disposal. Cost to the City would be 25 percent of alternative site cost if the selected area is not approved.

(c) Methods of Achieving Objectives

I. Michigan Statutory Law

a. Authority for Local Units of Government to Build, Own and Operate Waste Treatment Facilties:

1. Act 3, Public Acts of 1895 - *An act to provide for the incorporation of villages and to define their powers and duties.*

2. Act 215, Public Acts of 1895 - *An act to provide for the incorporation of cities of the fourth class and to define the powers and duties of such cities.*

3. Act 278, Public Acts of 1909 - *An act to provide for the incorporation of villages and for changing their boundaries; to provide for acquiring by purchase, land without its corporate limits necessary for the disposal of sewage and garbage. . .*

4. Act 279, Public Acts of 1909 - *An act to provide for the incorporation of cities and for revising and amending their charters.*

5. Act 116. Public Acts of 1923 - *An act to authorize townships to establish and maintain garbage systems or plants for the collection and disposal of garbage or contracting therefore, constructing or acquiring and maintaining sanitary sewers and sewage disposal plants; to provide for making, levying and collecting of special assessment bonds.*

6. Act 373, Public Acts of 1925 - *An act to authorize legislative bodies of municipalities to issue and sell bonds necessary for the construction of storm and sanitary sewers whenever a court of competent jurisdiction shall have ordered same.*

7. Act 320, Public Acts of 1927 - *An act to authorize legislative bodies of municipalities to issue and sell bonds necessary for the construction of sewage disposal plants whenever a court of competent jurisdiction shall have ordered same.*

8. Act 312, Public Acts of 1929 - *An act to provide for the incorporation by any two or more cities, villages or townships, or any combination or parts of same for supplying sewage disposal.*

9. Act 94, Public Acts of 1933 - *An act to authorize public corporations to purchase, acquire, construct, improve, enlarge, extend or repair public improvements within or without their corporate limits, and to own, operate and maintain the same; to provide for the issuance of bonds and refunding bonds payable solely from the revenues of public improvements; to provide for the imposition of special assessments against properties benefited by such public improvements, and for the issuing of special assessment bonds for the purpose of refunding outstanding revenue bonds.*

10. Act 342, Public Acts of 1939 - An act to authorize counties to establish and provide connecting water, sewer and/or sewage disposal improvements and services within or between cities, villages, townships and township improvement districts including disposal facilities and services and to provide methods for obtaining money for the aforesaid purposes.

11. Act 107, Public Acts of 1941 - An act to authorize township water supply and sewage disposal systems, and the issuance of revenue bonds or notes therefor.

12. Act 202, Public Acts of 1943 - An act relative to the borrowing of money by municipalities, and the issuance of bonds, notes and certificates of indebtedness; to provide for tax levies and sinking funds; to create the municipal finance commission; and to prescribe its powers and duties.

13. Act 245, Public Acts of 1947 - An act to regulate the ownership, extension, improvement and operation of public water and sewage disposal systems lying within two or more public corporations; and to provide for the payment and security of revenue bonds issued for the construction, acquisition, extension and improvement of such systems.

14. Act 359, Public Acts of 1947 - An act to authorize the incorporation of charter townships; to provide a municipal charter therefor; and to prescribe the powers and functions thereof including the installation of garbage disposal systems, the laying of storm and sanitary sewers and the installation of water systems.

15. Act 188, Public Acts of 1954 - An act to provide for the making of certain public improvements by townships; to provide for assessing the whole or a part of the cost thereof against property benefited; and to provide for the issuance of bonds in anticipation of the collection of such special assessments, and for the obligation of the township thereon.

    Improvements which can be made under this act include construction and maintainance of sewers.

16. Act 82, Public Acts of 1955 - An act to provide for the acquirement by a city of the water supply system and/or sewage disposal system of a metropolitan district and to permit such a city to own, maintain, operate, improve, enlarge and extend such systems either within or without its limits.

17. Act 233, Public Acts of 1955 - An act to provide for the incorporation of certain municipal authorities to acquire, own, extend, improve and operate sewage disposal systems and to provide for the issuance of bonds to acquire, construct, extend or improve sewage disposal systems.

18. Act 185, Public Acts of 1957 - An act to authorize the establishment of a department and board of public works in counties; to authorize the issuance and payment of bonds; and to prescribe a procedure for special assessments and condemnation.

19. Act 76, Public Acts of 1965 - An act to authorize counties, townships, villages, cities and any other governmental unit to construct waste disposal systems by agreements or contracts with governmental units or agencies of another state.

20. Act 191, Public Acts of 1970 - Amends Act 15, P.A. of 1961 by eliminating population limitation of 75,000 on counties. Permits local governments to require faster sewer connections for reasons of public health

b. Authority for the Control of Water Pollution:

1. Act 350, Public Acts of 1865 - An act to protect fish and to preserve the fisheries by preventing the unlawful dumping into the waters of certain materials.

2. Act 98, Public Acts of 1913 - An act providing for the supervision and control by the director of the department of public health over sewerage systems, and providing penalties for violations.

3. Act 17, Public Acts of 1921 - An act to provide for the protection and conservation of the natural resources of the state and to create a department of conservation.

4. Act 306, Public Acts of 1927 - An act to provide for county and district health departments; to prescribe their powers and duties; to provide for the apportioning of funds appropriated by the state, for aid to city, county and district health departments.

5. Act 245, Public Acts of 1929 - An act to create a water resources commission to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the great lakes, with power to make rules and regulations governing the same and to provide penalties for the violation of the act.

6. Act 61, Public Acts of 1939 - An act to provide for a supervisor of wells; to provide for the prevention of waste and for the control over certain matters, persons and things relating to the conservation of oil and gas and for the making and promulgation of rules, regulations, and orders relative therefor; to provide for the plugging of wells and for the entry on private property for that purpose; to provide for the enforcement of such rules, regulations and orders and of the provisions of this act and to provide penalties for the violations thereof; to prevent damage to or destruction of fresh water supplies and valuable brines by oil, gas, or other wastes; to require the disposal of salt water and brines and oily wastes produced incidental to oil and and gas operations, in such a manner and by such methods and means that no unnecessary damage or danger to or destruction of surface or underground resources shall result.

7. Act 222, Public Acts of 1949 - An act to authorize public corporations to accept grants and other aid from the U. S. Government and from industries for the construction of pollution abatement facilities; and to authorize public corporations to enter into contracts with industries for the use of disposal facilities.

8. Act 28, Public Acts of 1955 - Great Lakes Basin Compact. An act providing for cooperation of agencies of the state with the great lakes commission.

9. Act 247, Public Acts of 1955 - An act to authorize the department of conservation to regulate the filling in of submerged patented lands.

10. Act 40, Public Acts of 1956 - An act to codify the laws relating to drains, and such structures and mechanical devices as will properly purify the flow of such drains; and to provide for the assessment and collection of taxes.

11. Act 211, Public Acts of 1956 - An act to prescribe certain powers and duties of the water resources commission in making studies and investigations in the establishment of sewage disposal districts.

12. Act 243, Public Acts of 1959 - An act to regulate trailer coach parks; to prescribe the powers and duties of the director of the department of public health; and to provide remedies and penalties for violations.

13. Act 196, Public Acts of 1963 - An act to control and prohibit the littering of public and private property and waters.

14. Act 20, Public Acts of 1964 - An act to regulate the impoundment and utilization of surplus water and to prescribe certain powers and duties of the water resources commission.

15. Act 253, Public Acts of 1964 - An act to enable local units of government to cooperate in planning and carrying out a coordinated water management program in a watershed, and to prescribe certain powers and duties of the water resources commission.

16. Act 87, Public Acts of 1965 - an act to license and regulate garbage and refuse disposal and to provide penalties for violation.

17. Act 291, Public Acts of 1965 - An act to protect riparian rights and of the public trust in navigable inland lakes and streams; to regulate the uses thereof including dredging and placing spoil on bottom lands; and to prescribe the duties and powers of the department of conservation.

18. Act 222, Public Acts of 1966 - An act to provide for the exemption of industrial water pollution control facilities from certain taxes.

19. Act 329, Public Acts of 1966 - An act to provide state grants for sewage treatment facilities and to provide for administration of the grants by the water resources commission.

20. Act 218, Public Acts of 1967 - An act to protect the public health by providing for the supervision and control of bathing beaches open to the public; and to prescribe the functions of health agencies.

21. Act 288, Public Acts of 1967 - An act to regualte the subdivision of land; and to promote the public health by providing authority to the department of public health to approve subdivisons not served by public sewers on basis of suitability of soils.

22. Act 75, Public Acts of 1968 - An act to allow state grants for municipal sewage treatment works on a matching basis with the federal grant and to require that local agencies shall not receive a state grant until a comprehensive pollution control plan is approved by the water resources commission.

23. Act 76, Public Acts of 1968 - An act to authorize the issuance of general oblication bonds of the state of Michigan for the making of grants to municipalities of the state to be used in the construction and reconstruction of sewage treatment facilities; and to provide for the submission of the question of the issuance of said bonds to the electors of Michigan.

24. Act 167, Public Acts of 1968 - An act to regulate and control the obstruction of the stream beds and channels, and floodplains of the waters of the state.

25. Act 209, Public Acts of 1968 - An act requiring certification of the supervisors of industrial and commercial waste treatment facilities and providing for a measure of control of operation of these facilities by the water resources commission.

26. Act 21, Public Acts of 1969 - Amends Act 329, P.A. of 1966 to provide state assistance in the amount of 55 percent for construction of treatment works eligible for Federal participation under P.L. 84-660. Establishes State Water Pollution Fund of $285 million for this purpose.

27. Act 247, Public Acts of 1968 - To assist and encourage the acquisition of surface land areas and rights required for water quality control and other purposes in connection with mining and beneficiating low grade iron ore.

28. Act 58, Public Acts of 1969 - Eliminates restrictions on borrowing for sewers by villages. Extends repayment of special assessments over twenty installments and removes limitation of 25 percent of property value.

29. Act 89, Public Acts of 1969 - Eliminates restrictions on borrowing for sewers by 4th class cities. Extends repayment of special assessments over twenty installments and removes limitation of 25 percent of property value.

30. Act 136, Public Acts of 1969 - Requires license and bond for persons removing liquid industrial wastes from premises of another under Water Resources Commission; fee $100.00; vehicle must be inspected before it is licenses (fee $10.00); marked, violation punishable by fine and jail, etc.

31. Act 159, Public Acts of 1969 - Establishes $50 million state sewer construction fund to provide state grants to assist local agencies in the construction of collecting sewers. Grant would be for 50 percent of the cost of construction of collection sewers in excess of 10 percent of the state equalized value of all taxable property within the political boundaries of the unit served.

32. Act 167, Public Acts of 1970 - Prescribes use of nonpollutional holding tanks or incinerators on watercraft equipped with marine toilets; requires all marinas operating under permit from Department of Natural Resources and all marinas owned and/or operated or leased by the Michigan Waterways Commission to install pumpout facilities; regulates foreign and commercial vessels, regulates oil losses or discharges.

33. Act 127, Public Acts of 1970 - Natural Resource Conservation and Environmental Protection Act of 1969 provides a mechanism and procedures through declaratory judgment, etc., for equitable relief to protect air, water and other natural resources of the state from pollution.

35. Act 200, Public Acts of 1970 - Amends Act 245 of 1929 to remove a provision pertaining to bond sales that belongs and is now contained in Act 320 (Court Order Bond Act); to make voluntary agreements for pollution control enforceable the same as a Commission Order; to require registration of all manufactured products, production materials and waste products where certain wastes are discharged; to provide for surveillance fees upon discharges to the waters of the state in order to provide for investigation, monitoring and surveillance necessary to prevent and abate water pollution.

36. Act 214, Public Acts of 1970 - Amends Act 329, P.A. of 1966 to define "construction" to include cost of land where land is to substitute for chemical or mechanical facilities or both and if eligible for Federal funds under P.L. 84-660, but shall not include requisition of rights-of-way.

37. Act 234, Public Acts of 1970 - Adds "lake improvement" projects to those now permitted by County Public Works Departments.

2. State of Michigan Pollution Control Program

Administration of water pollution control functions in Michigan necessarily follows the division of statutory responsibility set forth in the previously cited statutes subject to correlation, whenever possible, of member department interests and objectives with those of the Water Resources Commission. The Water Resources Commission and the Department of Public Health and their respective staffs carry the principal burden of water pollution control in Michigan at the state level.

a. Water Resources Commission Pollution Control Program

Goal

The objective of the Michigan Water Resources Commission is to bring all existing unlawful pollution under continuing effective control and prevent the development of unlawful pollution from new sources, population growths, or increased industrial expansion and, where such incidents occur, limit their duration and intensity to the fullest extent consistent with requirements of the Water Resources Commission statute. Under the Michigan statute (Appendix A), it is unlawful for any person directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety or welfare; or which is or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters, or which is or may become injurious to the value or utility of riparian lands; of which is or may become injurious to livestock, wild animals, birds, fish, aquatic life or plants, or the growth or propagation therof be prevented or injuriously affecte; or whereby the value of fish and game is or may be destroyed or impaired. The discharge of any raw sewage of human origin, directly or indirectly into any waters of the state is prima facie evidence of a violation of the statute unless such discharge is permitted by an Order, rule or regulation of the Water Resources Commission.

Action Regarding Inadequacies

Where inadequacies in control of waste discharges are determined to exist, an opportunity is provided for establishement of voluntary corrective action. When it appears to the Michigan Water Resources Commission that a voluntary program will not be successful or may not be accomplished within a reasonable time period, statutory procedures are initiated. Orders adopted contain specific effluent restrictions and specific dates for approval of construction plans and specifications,

awarding of construction contracts and commencement of construction, and the completion of construction and attainment of pollution abatement as required by the Order.

Where noncompliance with the standards is determined to exist as the result of a discharge from an existing industrial or municipal wastewater treatment plant, treatment facilities adequate for meeting established water quality standards must be provided. Secondary treatment is required as a minimum for municipal discharges into interstate waters unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with present and future water uses. Exception to the requirement for at least secondary treatment must be justified to the satisfaction of the Michigan Water Resources Commission and the United States Environmental Protection Agency. Presently identified existing discharges of raw sewage of human origin to public waters must be corrected. Year-round disinfection of all final effluents from municipal sewage treatment plants is required. Industrial waste discharges must meet the same treatment requirements as municipal waste effluents and industrial waste problems identified must provide adequate treatment or control facilities.

Inspection and Facility Approval

The Water Resources Commission staff inspects each incipient pollution problem regularly. All Orders now adopted by the Commission to both industries and municipalities, require routine analysis and reporting of the quality of wastes discharged to public waters. In addition, surface water quality and waste effluents are monitored so as to identify the need for corrective action to abate existing problems and whenever possible so as to detect and identify the approach of pollutional conditions in time to initiate appropriate corrective action prior to the development of a statutory injury. The Water Resources Commission staff reviews and approves or rejects plans for industrial waste treatment or control facilities and counsels with management on industrial waste treatment or disposal problems. It develops appropriate restrictions and time schedules for Commission approval to correct or prevent pollution problems and participates in enforcement procedures initiated by the Commission through statutory hearings and enforcement of Commission Orders in court when voluntary compliance is not forthcoming.

Mandatory Certification of Industrial Treatment Plant Operators

Act 209, Public Acts of 1968, requires that all industrial or commercial establishments discharging liquid wastes into the waters of the State shall have waste treatment facilities under the specific supervision of persons who have been certified by the Water Resources Commission as properly qualitifed to operate the facilities. It further requires that monthly operating reports shall be filed with the Commission showing the effectiveness of the treatment facility operation and the quantity of the wastes discharged. Implementation of this program is now under operation by the Commission with assistance by an industrial management advisory committee.

Data Processing

The Michigan Water Resources Commission is now developing data storage and retrieval systems. Full consideration is being given to the systems now employed by the Ontario Water Resources Commission and the United States Government so as to afford easy exchange of data and cooperative use of the three systems. Reporting forms are in the final stages of preparation and the entire system will hopefully be operational in about three years.

CONSTRUCTION GRANT PROGRAM

The Commission maintains a grant administrator whose responsibilities include assisting municipalities in all phases of the construction grant program. Prospective applicants are advised of state and federal grant programs currently in effect for sewage treatment works, where to obtain and file applications and are kept advised of all program developments of importance. Under administrative rules of the Commission, grants are allocated by the administrator according to priority points assignment. The administrator also certifies projects to the State Treasurer, serves as intermediary between the city and the United States Environmental Protection Agency for federal grants and makes inspections of grant projects.

No financial assistance for maintenance of pollution control facilities is provided by the state. Technical assistance is provided by the Department of Public Health, Division of Engineering. Instruction in maintenance of specific pieces of treatment plant equipment is provided through the Department's operator training program.

The state also provides for the exemption of water pollution control facilities from certain taxes.

All applications for water pollution control tax certificates are filed with the State Tax Commission, but are referred to the Water Resources Commission for approval. If the Water Resources Commission finds that the facility is designed and operated primarily for the control, capture and removal of industrial wastes from the waters, and is suitable, reasonably adequate and meets the intent and purposes of the Water Resources Commission statute, it so notifies the State Tax Commission who then issues the certificate.

A facility covered by a tax certificate is exempt from personal property taxes, and tangible personal property which becomes affixed and made a structural part of the real estate of such facility is exempt from sales and use taxes.

Provisions are made in the Act for modification or revocation of the certificate under certain conditions.

Combined Sewerage Systems

New sewerage systems must be developed on the basis of separate sewers for stormwater and sanitary wastewater. When at all feasible separated sanitary wastewater systems shall not be discharged into combined systems. If such discharge does occur control facilities must be developed on the combined system so as to protect present and future water uses of the receiving waters consistent with the requirements of the Water Resources Commission statute. Problems associated with the overflow of storm and sanitary waste from existing combined public sewers in the Lake Michigan, Lake Superior and Lake Erie basins must be corrected on or before June 1, 1977.

Nutrients in Municipal and Industrial Waste Discharges

Nutrient discharges, particularly with respect to phosphates, to public waters must be controlled. Persons proposing to make a new or increased use of waters of the state for waste disposal purposes are required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and as a long-term objective, all existing waste dischargers will be required to provide facilities for the removal of phosphorus compounds by December, 1972. See Page 86 for further discussion.

Control of New Waste Discharges

The Michigan Water Resources Commission will prevent the development of new problems by continued implementation of Section 8(b) of its statute which requires the filing of a statement of use by any person proposing to make a new or substantial increase in use of waters of the state for waste disposal purposes. The Commission, upon receipt of a statement, makes an Order stating such minimum restrictions as may be necessary to guard adequately against unlawful uses of waters of the State.

Water Quality Standards

Water quality standards and use designations for all inter- and intrastate waters have been adopted. Water use designations together with a plan of implementation and enforcement of the standards were adopted for interstate waters on June 28, 1967, while the intrastate water standards were adopted on January 4, 1968. The use designations for intrastate waters were established on March 20, 1969. A series of five water and related land resource inventory reports were compiled by the staff of the Water Resources Commission and were used, along with other supporting data, as background material for determining use designations.

Watercraft Pollution Control
(Act 167, Public Acts of 1970)

The "Watercraft Pollution Control Act of 1970" was passed by the Michigan Legislature and signed into law August 4, 1970. This law strengthened and expanded the watercraft pollution control program already in effect under the Water Resources Commission's Administrative Rules. It is of special interest to all Michigan watercraft owners and marina operators, since it spells out certain requirements for all vessel and marina owners in the state.

Effective January 1, 1971, all toilet equipped watercraft moored or operated on the State's waters (including cargo-carrying vessels, interstate and international vessels, documented vessels, and pleasure watercraft) must be equipped with one of the following pollution control devices:

a. A holding tank which will retain all sewage produced on the watercraft for subsequent on-shore disposal at an approved sewage disposal facility.

b. A recirculating, self-contained marine toilet (permanently attached or portable) which will retain all sewage produced on the watercraft for subsequent on-shore disposal at an approved sewage disposal facility.

c. An incinerating device which will reduce to ash all sewage produced on the watercraft. Ash remains must be disposed at an appropriate receptacle on shore.

No person may own, operate, or permit the operation of any marine sanitation device which will directly or indirectly discharge treated or untreated sewage into the inland or Great Lakes waters of the State. The macerator-chlorinator is not an approved sanitation device.

Since holding tanks and self-contained marine toilets require periodic pumping out, the new law provides that all private marinas or docks that have facilities to handle 15 or more watercraft of the size capable of being equipped with a marine toilet, operating on the bottomlands of the State's waters under permit or lease from the Department of Natural Resources, shall be equipped with an approved pump-out facility to service those watercraft. Failure to comply with this provision may be just cause for revocation of the permit or lease to operate. All state and local public marinas must also be equipped with pump-out facilities if deemed necessary. Pump-out facilities are already available at most state assisted public marinas and many private marinas and yacht clubs.

Oil and litter discharges from vessels are also covered under the provisions of the Act. Any vessel discharging oil or oily wastes must immediately take steps to clean up such discharge or be liable to the State for any costs incurred for its removal.

Failure to comply with any of the provisions of the Act may result in a citation and fine of up to $500.00.

WATER RESOURCES COMMISSION'S POLICY ON PHOSPHATE REMOVAL

The Water Resources Commission's pollution control program concerning phosphate removal was established in October, 1967, when the following policy was adopted:

WHEREAS, Nutrients released to our water environment are a contributing factor to an accelerated rate of aging of inland lakes and streams, including the Great Lakes, as evidenced by growths of aquatic weeds and algae; and

WHEREAS, phosphorus is an essential element to such growths;

THEREFORE BE IT RESOLVED, that persons proposing to make a new or increased use of waters of the state for waste dispsoal purposes will be required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and that as a long-term objective, all existing waste dischargers will be required to provide facilities for the removal of phosphorus compounds by December, 1972.

The nutrient policy as applied to stabilization lagoons was adopted at the November-December meeting of the same year and reads as follows:

"Generally, these requirements may be reasonably met by waste stabilization lagoons in small communities and others where the lagoons will provide equal or greater assurance of meeting established water quality objectives for the receiving waters (other than nutrients) than may be provided by other types of treatment facilities for such conditions.

The waste stabilization lagoon process does not provide a high degree of removal of phosphates, therefore, such installations may not be adequate for discharge of the effluent of certain locations such as inland lakes and impoundments.

When practical methods are developed for effective removal of phosphates in the lagoon process by modification of design features or by process control methods, owners of any such facilities will be required to incorporate and utilize such features and methods."

b. Department of Public Health Pollution Control Program

The Department of Public Health, acting through its Division of Engineering, exercises supervisory control over all public sewerage systems. The Director of the Department is required by statute, Act 98, Public Acts of 1913, as amended, to "exercise due care to see that all sewerage systems are properly planned, constructed and operated so as to prevent unlawful pollution of the streams, lakes and other water resources of the state". The companion statute, Act 245, Public Acts of 1929, as amended, defines unlawful pollution and authorizes the Water Resources Commission to "establish such pollution standards for lakes, rivers, streams, and other waters of the state in relation to the public use to which they are or may be put, as it shall deem necessary". Such pollution standards and the water quality criteria relating to the public uses, recently approved for both interstate and intrastate streams, provide the framework upon which decisions are made and actions taken in relation to the planning, design, construction and operation of all sewer systems and treatment works. Elements of this supervisory program include the following:

Facilities Planning and Approval

1. Review engineering reports establishing the basis of design for projects involving collection and treatment of wastewater and consult with the engineers and municipal officials on elements of the proposed design prior to development of plans and specifications for the project, require modification of proposed design where appropriate and, when found to be satisfactory, approve same.

2. Review, approve or reject and secure changes in plans and specifications submitted for new municipal systems or for changes in existing systems, both for collection and treatment. No public sewerage system may be built or altered without specific approval by construction permit.

3. Conducts inspections to determine that construction of public sewerage systems conforms to approved plans and specifications.

4. Require reduction of overflows from existing combined sewer systems. Adoption of accelerated programs for effective control of overflows from such systems is strongly urged.

5. Require municipal rather than private ownership of all sewerage systems serving the public in the belief that more dependable and effective operation and overall pollution control is thereby assured.

6. Counsels with officials of municipalities and their consulting engineering agents as to the need and methods for collection and treatment of wastewater.

7. Strongly encourage and, where appropriate, require the development of multicommunity area planning to provide effective services and pollution control facilities utilizing sound management principles. Many such areas are currently served by an integrated system of sewers, interceptors, and treatment works. Others are being so planned in several areas.

8. Encourage the admission of industrial wastes in municipal sewerage systems where such wastes will not adversely affect the system and its performance in relation to effective pollution control.

9. Foster, encourage and assist communities in the adoption of effective and practical sewer use ordinances for the control of industrial wastes to be admitted to the sewerage system. In many instances, technical assistance and counsel is provided in the location, analyses, evaluation, and pretreatment of wastes, particularly those detrimental to biological treatment processes and in the development of effective corrective measures and controls.

10. Encourage, and where appropriate, require communities to conduct studies, pilot or plant scale, to provide a dependable basis of design for unusual combinations of industrial and municipal wastes to be treated where sufficient information is not available for design purposes.

11. Encourage and assist communities to conduct studies to establish effective methods for removal of phosphates from their wastes at existing treatment works. In the last year, several communities have purchased spectronic equipment and are obtaining background data on phosphates in their wastes. Some are doing bench scale tests on phosphate removal with iron and aluminum salts.

12. Require facilities for removal of phosphates in design of new treatment works, consistent with the adopted policy of the Water Resources Commission.

13. Require expansion and improvements of municipal facilities, both for collection and treatment as present capacity is approached, rather than wait until the facilities are overloaded before taking action. Approval of sewer extensions is withheld where additional loadings would exceed the capacity of the system until an acceptable program for relief is officially adopted. "Sewer bans" have been imposed in such circumstances. Authority for such action has been tested and upheld in the courts.

14. Order changes in facilities or their operation when requirements of the statutes have not been met. Alternatively, cases involving deficiency in facilities are referred to the Water Resources Commission for action.

15. As agent for the Water Resources Commission, review, approve or reject plans submitted for new sewer systems, other than municipal, or for changes in existing ones.

16. Assist and encourage local health departments to effectively direct and control the installation of private sewage disposal systems where public sewer sytems are not available for connection.

17. Require construction of separate sanitary sewers for new community systems.

<u>Facility Operation - Supervision, Visitation</u>

1. Require the effective operation of all treatment works, including pumping stations and sewer system appurtenances.

2. Require all municipalities to submit reports monthly on the operation of treatment works. Standard report forms are provided by the Department and each municipality is advised as to the minimum information to be reported and the frequency (number of days per week) of reporting. Included are both physical data and laboratory analyses to establish loadings on the plant, performance of plant units, and the volume and

characteristics of the plant effluent . Report forms are presently being revised to include chemical analyses, including phosphorus data (Appendix E). Such information is used to determine effectiveness of overall plant performance, deficiencies of component facilities, capacity reserves for additional loadings, and operational problems and shortcomings. Action is taken to assist in corrective measures and to require correction.

3. Supervise operation by on-site inspection, instruction and consultation with plant operating personnel. Adequate services of this nature requires visitation once during each three months on the average.

Privately-Owned Public Sewerage System Policy

1. Require private developers of public sewerage facilities to obtain authorization and approval from the township board as to all related matters as required by the constitution, applicable laws, and local ordinance.

2. Require a plan for the effective and continuous operation of the facilities by the owner.

3. Require a resolution by the township board that it will assume complete responsibility for the effective operation and maintenance and make any necessary repairs, replacements, extensions or improvements to the facilities which are required in the public interest if the private owner should fail to do so.

Operator Certification and Training

1. Require all municipalities to employ operators whose competency has been certified by the Department. By statute, it is mandatory that the person in charge of the plant be so certified. Over 600 operators have been so certified on the basis of education, experience, and written examinations. About 200 operators with plant experience are examined each year. A high percentage of applicants are certified operators seeking to establish qualifications for a higher plant classification.

2. Conduct formal group training sessions to impact specific information related to effective operational control, to provide opportunity for exchange of information and experience and to provide incentives for self-study and development. Over 325 operators attend a 2-day meeting each year conducted by Department engineers and chemists. A series of four 5-day sessions in laboratory procedures involving chemical and bacteriological analyses have been conducted concurrently with four 5-day sessions in colorimetry by the Department staff during January and February the past two years; 225 operators who presently perform such tests at their plants registerd for these short courses. Evening courses are held throughout the state for a 12-week period in mathematics, chemistry or hydraulics as applied to wastewater works operation, in a cooperative program with other agencies and organizations. Special courses in process control, safety, and related areas are sponsored with other groups.

3. Encourage operators to meet on a regular schedule, usually about once monthly, on their own initiative to exchange information on plant operational problems and experiences and to invite speakers to discuss

selected subjects related to facilities design and maintenance, laboratory equipment, etc. About ten such groups meet regularly with about 200 operators participating.

Disinfection Policy and Practice

1. Require all municipalities to disinfect the plant effluent before discharge to the surface waters of the state. This policy was adopted in January 1967. Virtually all communities in the state are conforming to this policy.

2. Require the provisions of adequate facilities and their operation, monitoring, and testing in such a manner as to assure continuous effective disinfection.

3. Require regular reporting on forms furnished by the Department of chlorine used daily, results of chlorine residual readings, and related information. Most communities are performing bacteriological analyses on the chlorinated effluent as a check on the chlorine dosage and chlorine residual regimens. Other small communities are currently planning to apply additional refinements in control this year.

Recommendation of the Third Session of the Conference on Pollution of Lake Michigan and the Tributary Basins.

RECOMMENDATION

Waste treatment is to be provided by all municipalities to achieve at least 80 percent reduction of total phosphorus and to produce an effluent that will not result in degradation of Lake Michigan's water quality. Such treatment will provide compliance with the water quality standards for Lake Michigan as approved by the Secretary of the Interior and the appropriate State water pollurion control agency of Illinois, Indiana, Michigan or Wisconsin. This action is to be substantially accomplished by December, 1972.

Action Taken

On February 5, 1968, letters were sent to all municipalities which have wastewater treatment plants discharging to the surface waters of the State. The letter transmitted a copy of the Resolution adopted by the Water Resources Commission in October, 1967, calling for removal of phosphorus compounds from waste discharges by June 1, 1977. It also pointed out that June 1, 1977 was an outside date for meeting the objective and that earlier compliance should be sought wherever possible.

On June 3, 1968, letters were sent to communities of 2,000 population or larger within the Lake Michigan basin advancing the date for phosphorus removal to December, 1972, in conformance with the Secretary's recommendation. Those communities within the basin, and discharging to interstate waters, were also apprised of the need to provide secondary treatment by June 1, 1972, unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with present and proposed future uses as defined by the Federal-State interstate water quality standards.

Formal Stipulations were sent to communities which responded favorably to the requests for improved treatment. The Stipulations formalize an orderly study, design and construction program with performance dates consistent with the Secretary's recommendation. Communities not proceeding voluntarily have appeared before the Commission and Orders of Determination have been adopted against all of these with populations greater than 2,000.

3. Pollution Control of Water Within the Grand River Basin.

Table V-7 presented earlier outlines the pollution control plan for the Grand River basin. A set of maps showing municipal and industrial discharge points accompanies the table. In addition, a set of tables identifying the agencies responsible for implementing the plan are included on the following pages.

A separate metropolitan pollution control plan has been submitted for Jackson and additional metropolitan plans will be submitted for the Lansing and Grand Rapids metropolitan areas.

Table V-11

PENDING APPLICATIONS GRAND RIVER BASIN

WPC-MICH	APPLICANT	1960	1970	Served 1970	1980	1990	2000	MGD DESIGN FLOW	COSTS OM	TOTAL ELIGIBLE
1885	Algoma Township	2,485	3,072	400		600		.06*	2,500	137,500
1746	Grand Haven - Spring Lake	13,129	15,200	11,250	17,350	20,975		2.3*	175,000	4,852,400
1760	Coopersville	1,584	2,126		2,740	3,880		.4*	10,000	235,500
1731	Ottawa County - Allendale		1,308	1,308	7,000			.7*	22,000	659,000
1724	Grand Rapids	203,000	213,800	235,700		350,000		90	643,000	14,500,000
1734	Wyoming	45,712		111,960		190,000		19	681,000	7,764,000
1883	Grandville	8,000	10,800	8,200	20,500			3.2	30,000	1,200,000
1738	Casnovia	371	417	375			560	.06*	3,000	103,000
1900	Kent County - Gaines Township(Dutton)		350	350		800		Interceptors	5,400	216,180
1899	Kent County - Ada Township	2,887	4,557	1,018		2,700		.3*	3,400	190,000
1931	Kent County - Cannon Township	2,525	3,716	1,860	5,500	6,600	8,000	Interceptors	20,800	1,430,000
1720	Caledonia	739	750	750	1,100	1,400		.05	6,000	267,000
1838	Nashville	1,525	1,600	1,600	1,750	2,000		.5	18,500	144,700
1910	Bowne Township	1,181	1,270	327		396		.5*	2,000	90,700
1728	Lowell	2,545	3,051	3,051	3,600	4,190		.8	8,500	33,000
1716	Clarksville	371	400	400		490		.04	3,500	359,500
1845	Ionia									
1924	Muir									
1803	Portland									
1869	Eaton County - Mulliken	484	500		750	1,000		.2*	4,000	200,500
1761	Eaton County - Delta Township	7,627	17,247	9,500	36,500			4	235,000	2,400,000
1878	Eaton County - Sunfield	626	700		700		1,400	.2*	2,500	270,152
1856	Grand Ledge	5,165	6,000	6,000	8,000			1.0	39,500	250,000
1944	Gratiot County - Fulton Township	1,680	1,780	750	1,400			.15*	2,500	691,000
1842	Clinton County - Bath Township									
1843	Clinton County - Watertown Township		3,137	688		979		Treated at Dewitt	4,000	1,319,000
1841	Clinton County - Elsie									
1909	Crystal Township Dist. #1	1,557	1,750	1,326		2,320		.25*	6,500	353,500
1908	McBride	265	269	230		326		.04*	2,000	72,100
1846	Lansing	120,348	135,646	135,646		200,000			136,000	660,000
1823	East Lansing	44,097	89,793	88,000	104,700			15.65		1,240,000
1871	Ingham County - Williamston	2,214	2,800	2,750	4,000	5,000		.5	41,000	608,000

Table V-11 (Cont'd)

WPC-MICH	APPLICANT	1960	1970	Served 1970	1980	1990	2000	MGD DESIGN FLOW	COSTS OM	COSTS TOTAL ELGIBLE
1802	Mason	4,522	5,483	5,483		8,360		1.2	85,000	500,000
1864	Jackson County - Parma	770	800	800				.1*	7,500	186,000
1887	City of Jackson		50,000	50,000	105,000	123,100	162,200	17	365,000	4,270,000
1866	Jackson Metro Area									
1732	Grass Lake	1,037	1,100	1,100				.1*	4,500	224,200
1740	Gratiot County - Perrinton	421	500	500		600		.06*	2,560	235,800

*Design flow estimated: 100 gal/day/person

Table V-11

AGENCY RESPONSIBLE FOR IMPLEMENTING PLAN

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Grand Haven-Spring Lake	Municipal		Bonds WRC EPA	Grand Haven Spring Lake	Grand Haven Spring Lake	Grand Haven - Spring Lake and Michigan Department of Public Health
Coopersville	Municipal		Bonds WRC EPA	Coopersville	Coopersville	Coopersville and Michigan Department of Public Health
Grandville	Municipal	Bonds WRC EPA		Grandville	Grandville	Grandville and Michigan Department of Public Health
Wyoming	Municipal	WRC EPA		Wyoming	Wyoming	Wyoming and Michigan Department of Public Health
Grand Rapids	Municipal		Bonds WRC EPA	Grand Rapids	Grand Rapids	Grand Rapids and Michigan Department of Public Health
Ottawa County (Eastmanville)	Ottawa County Infirmary		Ottawa Co. Bd. of Comm. WRC EPA	Ottawa County	Ottawa County	Ottawa County and Michigan Department of Public Health
Kentwood	Municipal	Bonds WRC EPA		Kentwood	Kentwood	Kentwood and Michigan Department of Public Health
Kent County	Gaines Township (Dutton)		Kent Co. DPW WRC EPA	Kent County	Kent County	Kent County and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Kent County	Cannon Township	Kent Co.DPW		Kent County	Kent County	Kent County and Michigan Department of Public Health
Kent County	Ada Township	WRC EPA		Kent County	Kent County	Kent County and Michigan Department of Public Health
Lowell	Municipal	Bonds WRC EPA		Lowell	Lowell	Lowell and Michigan Department of Public Health
Saranac	Municipal			Saranac	Saranac	Saranac and Michigan Department of Public Health
Ionia	Municipal	WRC EPA		Ionia	Ionia	Ionia and Michigan Department of Public Health
Portland	Municipal		WRC EPA	Portland	Portland	Portland and Michigan Department of Public Health
Eaton County BPW	Mulliken (Municipal)		WRC EPA Eaton County BPW	Eaton County	Mulliken	Eaton County and Michigan Department of Public Health
Grand Ledge	Municipal	Bonds WRC EPA		Grand Ledge	Grand Ledge	Grand Ledge and Michigan Department of Public Health
Lansing	Municipal	WRC EPA (1971)	WRC EPA (1970)	Lansing	Lansing	Lansing and Michigan Department of Public Health
Eaton County BPW	Dimondale (Municipal)		WRC EPA	Eaton County	Eaton County	Eaton County and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Eaton Rapids	Municipal			Eaton Rapids	Eaton Rapids	Eaton Rapids and Michigan Department of Public Health
Eaton County BPW	Delta Township (Municipal)		Eaton Co.BPW WRC EPA	Eaton County	Delta Township	Eaton County and Michigan Department of Public Health
Ingham County DPW	Delhi Township (Municipal)			Ingham County	Ingham County	Ingham County and Michigan Department of Public Health
Leslie	Municipal			Leslie	Leslie	Leslie and Michigan Department of Public Health
Jackson	Municipal		Bonds WRC EPA	Jackson	Jackson	Jackson and Michigan Department of Public Health
Grass Lake	Municipal	Bonds WRC EPA		Grass Lake	Grass Lake	Grass Lake and Michiga Department of Public Health
Jackson County DPW	Parma		WRC EPA	Jackson County	Parma	Jackson County and Michigan Department of Public Health
Spring Arbor College	Spring Arbor College			Spring Arbor College	Spring Arbor College	Spring Arbor College and Michigan Departmen of Public Health
Jackson County DPW	Blackman Township Summit Township Spring Arbor Township Leoni Township	WRC EPA		Jackson County	Jackson County	Jackson County and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
ROGUE RIVER						
Rockford	Municipal		WRC EPA	Rockford	Rockford	Rockford and Michigan Department of Public Health
Kent County DPW	Algoma Township (Municipal)	Bonds WRC EPA		Kent County	Kent County	Kent County and Michigan Department of Public Health
Cedar Springs	Municipal		Kent Co. WRC EPA	Cedar Springs	Cedar Springs	Cedar Springs and Michigan Department of Public Health
Kent City	Municipal			Kent City	Kent City	Kent City and Michigan Department of Public Health
Sparta	Municipal			Sparta	Sparta	Sparta and Michigan Department of Public Health
Casnovia	Municipal	Bonds WRC EPA		Casnovia	Casnovia	Casnovia and Michigan Department of Public Health
THORNAPPLE RIVER						
Caledonia	Municipal	Bonds WRC EPA		Caledonia	Caledonia	Caledonia and Michigan Department of Public Health
Lake Odessa	Municipal		Bonds WRC EPA	Lake Odessa	Lake Odessa	Lake Odessa and Michigan Department of Public Health
Clarksville	Municipal	Bonds WRC EPA		Clarksville	Clarksville	Clarksville and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility Location	Source	Financing (Requested)	Financing (Granted)	Construction	Operation	Evaluation
Middleville	Municipal		WRC EPA	Middleville	Middleville	Middleville and Michigan Department of Public Health
Hastings	Municipal	Bonds WRC EPA		Hastings	Hastings	Hastings and Michigan Department of Public Health
Woodland	Municipal			Woodland	Woodland	Woodland and Michigan Department of Public Health
Eaton County BPW	Sunfield (Municipal)		Eaton Co. BPW WRC EPA	Eaton Co.	Sunfield	Eaton County and Michigan Department of Public Health
Kent County	Bowne Township (Municipal)	Kent Co.DPW Bonds WRC EPA		Kent County	Kent County	Kent County and Michigan Department of Public Health
Nashville	Municipal	Bonds WRC EPA		Nashville	Nashville	Nashville and Michigan Department of Public Health
Vermontville	Municipal		FHA WRC	Vermontville	Vermontville	Vermontville and Michigan Department of Public Health
FLAT RIVER						
Belding	Municipal		Bonds WRC	Belding	Belding	Belding and Michigan Department of Public Health
Greenville	Municipal	WRC EPA		Greenville	Greenville	Greenville and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Kent County DPW	Sand Lake (Municipal)			Kent County	Kent County	Kent County and Michigan Department of Public Health
McBride	Municipal	Bonds WRC EPA		McBride	McBride	McBride and Michigan Department of Public Health
Edmore	Municipal			Edmore	Edmore	Edmore and Michigan Department of Public Health
MAPLE RIVER						
Lyons-Muir	Municipal	WRC EPA		Lyons-Muir	Lyons-Muir	Lyons-Muir and Michigan Department of Public Health
Fowler	Municipal		Bonds WRC EPA	Fowler	Fowler	Fowler and Michigan Department of Public Health
St. Johns	Municipal			St. Johns	St. Johns	St. Johns and Michiga Department of Public Health
Carson City	Municipal		WRC EPA	Carson City	Carson City	Carson City and Michigan Department of Public Health
Montcalm County	Crystal Township (Municipal)	Montcalm Co. WRC EPA		Montcalm County	Drainage Dist.	Montcalm County and Michigan Department of Public Health
Stanton	Municipal			Stanton	Stanton	Stanton and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Clinton D.P.W.	Maple Rapids (Municipal)	Clinton Co. WRC EPA		Maple Rapids	Maple Rapids	Maple Rapids and Michigan Department of Public Health
Gratiot County	Perrinton (Fulton Township)	Gratiot Co. WRC EPA		Gratiot County	Perrinton	Gratiot County and Michigan Department of Public Health
Clinton County D.P.W.	Elsie (Municipal)	Clinton County WRC EPA		Clinton Co.	Elsie	Clinton County and Michigan Department of Public Health
Gratiot County	Ashley (Municipal)		Gratiot Co. WRC EPA	Gratiot Co.	Ashley	Gratiot County and Michigan Department of Public Health
Westphalia	Municipal	Clinton Co. WRC EPA		Westphalia	Westphalia	Westphalia and Michig Deparmtent of Public Health
LOOKING GLASS RIVER						
Dewitt	Municipal			Dewitt	Dewitt	Dewitt and Michigan Department of Public Health
Clinton County D.P.W.	Dewitt Township (Municipal)		Clinton Co.	Clinton Co.	Clinton Co.	Clinton County and Michigan Department of Public Health
Clinton County D.P.W.	Watertown Township (Municipal)	Clinton Co. WRC EPA		Clinton Co.	Clinton Co.	Clinton County and Michigan Department of Public Health
Clinton County D.P.W.	Bath Township (Municipal)	WRC EPA		Clinton Co.	Clinton Co.	Clinton County and Michigan Department of Public Health

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Laingsburg	Municipal		WRC EPA	Laingsburg	Laingsburg	Laingsburg and Michigan Department of Public Health
Perry	Municipal		WRC EPA	Perry	Perry	Perry and Michigan Department of Public Health
RED CEDAR RIVER						
East Lansing	Municipal	Bonds WRC EPA		East Lansing	East Lansing	East Lansing and Michigan Department of Public Health
Mason	Municipal	Bonds WRC EPA		Mason	Mason	Mason and Michigan Department of Public Health
Ingham County DPW	Williamston (Municipal)		Ingham Co. WRC EPA	Williamston	Williamston	Williamston and Michigan Department of Public Health
Fowlerville	Municipal			Fowlerville	Fowlerville	Fowlerville and Michigan Department of Public Health
Webberville	Municipal			Webberville	Webberville	Webberville and Michigan Department of Public Health

Industries receive no financial assistance for construction of treatment works. In all cases in the Grand River Basin construction and operation of an industrial waste treatment facility is the responsibility of the industry concerned. Evaluation is done by the industry and Water Resources Commission staff.

Table V-12 (Cont'd)

Treatment Facility		Financing				
Location	Source	(Requested)	(Granted)	Construction	Operation	Evaluation
Kent County	Byron Township Municipal		Bonds Kent Co.	Kent County	Kent County	Kent County and Michigan Department of Public Health
Potterville	Municipal		WRC EPA	Potterville	Potterville	Potterville and Michigan Department of Public Health
Ottawa County	1.Grand Valley State College 2.Allendale Township 3.Georgetown Township	WRC EPA		Ottawa Co. Road Comm.	Ottawa Co. Road Comm.	Ottawa Co. Rd. Comm. and Michigan Departme of Public Health
Ovid	Municipal		WRC EPA	Ovid	Ovid	Ovid and Michigan Department of Public Health
Ravenna	Municipal		WRC EPA	Ravenna	Ravenna	Ravenna and Michigan Department of Public Health
Ottawa County	Wright Township (Marne) Municipal		FHA WRC	Ottawa County	Ottawa County	Ottawa County and Michigan Department of Public Health

C. Advanced Treatment Needs in the Grand Basin

Six general areas in the Grand River Basin are anticipated to require advanced waste treatment before the year 2000. Two of these areas will need advanced treatment between now and 1980. These areas either are located near streams having low drought flows or handle large quantities of wastewater and discharge to moderate size rivers.

In terms of this report, advanced waste treatment is defined as treatment over and above phosphorus removal and "secondary" or standard biological treatment which removes at least 90 percent of the organic constituents as measured by the standard 5-day BOD test. Advanced waste treatment is considered necessary when the residual BOD loading from a secondary treatment plant will depress the dissolved oxygen level in the receiving stream below that specified by water quality standards when the flow in the receiving stream is less than or equal to the 7-day average low flow expected to occur once in 10 years.

For the areas specified as requiring advanced treatment after 1980 but before 2000, it should be noted that a great deal of additional data and study is required to adequately document and verify many of the specific problems.

Because the Water Resources Commission and the Department of Public Health are enforcement and approval agencies, the determination of the kind of treatment suitable for each of these communities is the task of consultant engineers hired by the communities. The Department of Public Health and the Water Resources Commission review the engineering reports to see if the alternatives were sufficiently reviewed by the engineer. The treatment proposed by the community is then evaluated to insure that the effluent will meet water quality standards and that the means of treatment is reasonable, in terms of cost, as compared to other alternatives.

The following is a list of communities requiring advanced treatment or alternatives to additional treatment within the Grand Basin. The listed alternatives have been suggested by the consultant engineers and by the staff of the Michigan Department of Public Health and the Water Resources Commission. Final plans describing the type treatment to be provided are reviewed and approved or disapproved by the Department of Public Health and the Water Resources Commission. Only grant applications with approved plans are submitted to the Federal Government. Those disapproved are returned to the community for revisions or further review of other alternatives.

Community	Alternatives
Jackson	1. Secondary treatment w/ sand filters 2. Secondary treatment w/ effluent ponds 3. Secondary treatment w/ micro strainers 4. Secondary treatment w/ spray irrigation 5. Secondary treatment w/ nitrification and extended aeration.

Alternative #5 was proposed and adopted by the City and has been approved by the Department of Public Health and the Water Resources Commission.

East Lansing (Includes Meridian Township)

Alternatives 1-5 are based on provision of teritary treatment by carbon adsorption and nitrification.

1. East Lansing, Mason, combine and treat at East Lansing, abandon Mason plant.

2. East Lansing, Delhi Township, Mason, Combine and be treated at East Lansing plant, abandon other two plants.

3. Delhi Township and Mason, combine and treat at Lansing Plant, abandon Delhi and Mason Plants.

4. East Lansing, Lansing, Mason, Delhi Township; abandon East Lansing, Mason and Delhi Plants, treat combined wastes at Lansing Plant.

5. East Lansing, Lansing, Mason, Delhi Township, Watertown Township, combine and treat at Lansing, abandon other plants.

6. East Lansing treat only their wastes and Meridian Township using advanced treatment - mixed media filters.

Alternative #6 has been proposed by the City. It is now being reviewed by the Department of Public Health and the Water Resources Commission.

Costs for Wastewater Treatment Alternatives Involving East Lansing

Alternative	Total Cost for the Alternative ($1 Yr.)	Total Cost for Individual Treatment ($1 Yr.)
1	$2,568,000	$2,595,000
2	2,977,500	3,213,000
3	4,163,000	4,405,000
4	6,224,500	6,802,000
5	6,238,500	6,822,000
6	-	2,397,000

Williamston

1. Waste stabilization ponds
2. Activated sludge with extended aeration
3. Biological oxidation towers

Alternative #2 was proposed and adopted by the City. Plans were approved by the Department of Public Health and the Water Resources Commission. Construction grants have been received by the City and construction began in June 1971.

Mason

1. Interceptor to East Lansing treatment facility
2. Interceptor to Lansing Treatment facility
3. Combination of one and two
4. On land disposal

Mason has not submitted plans to provide for advanced treatment at this time. However, the above alternatives are being looked at by the Water Resources Commission to be placed in operation in Mason.

Delta Township

1. Transport secondary effluent to finishing plant in Lansing area
2. Enlarge secondary facility with physical provisions to allow addition of tertiary processes.

Alternative #2 was proposed and adopted by the Township. Approval was given by the Department of Public Health and the Water Resources Commission. Federal-State construction grants have been received by the Township.

DeWitt-DeWitt Township

A maximum of 300 pounds per day BOD is permitted from the City of DeWitt and DeWitt Township combined to be discharged to the Looking Glass River. The Township is just completing a new secondary treatment facility. The City of DeWitt will soon need more than secondary treatment. If population projections hold true advanced treatment will be necessary in the near future.

Alternatives:
1. City of DeWitt to DeWitt Township.
2. Bath Township, Watertown Township, City of DeWitt. at an expanded DeWitt Township Plant.
3. DeWitt and DeWitt Township to Lansing.

Economically, Alternative #1 is most attractive. Plans have not been submitted for any of these alternatives to date.

Lansing

Tertiary treatment will be required by December,1974, for Lansing. Preliminary plans must be submitted by February 1, 1972.

Alternatives being considered in addition to or in conjunction with East Lansing alterantives 3, 4, and 5 are:

1. Physical-chemical treatment
2. Secondary treatment with sand filtration and extended aeration
3. Two stage, activated sludge for ammonia conversion.

All alternatives include construction of stormwater retention basin.

St. Johns

St. Johns is under Final Order to provide phosphorus removal by December 1, 1972. The City has further been advised that a higher degree of treatment (secondary with trickling filter is now provided) is necessary. St. Johns Drain which receives the effluent from the City's wastewater treatment plant has a low flow of zero.

No plans or alternatives to advanced treatment have been submitted by the City at this time. St. Johns has not filed a grant application.

It should be noted that those communities likely to require advanced waste treatment in the near future are all in the Lansing Metropolitan Area. A metropolitan water quality management plan will be completed for this area soon. Therefore, additional discussion of the advanced treatment needs is not deemed necessary in the basin plan.

4. Impact of the Proposed Waste Treatment on Water Quality.

The major sources of pollution and actions needed for abatement have been identified within the basin. Upon implementing the plan, water quality will be improved so as to meet water quality standards and protected uses in most of the surface water of the basin.

Water quality may still be deficient in some isolated areas where small unidentified sources of pollution occur. By abating the major sources of pollution, the smaller pollution sources will be more readily identifiable and action will be taken to correct them.

There are stretches of streams within the basin where natural water quality may at times be lower than certain parameters of water quality standards specified for a designated use. However, it is intended that the water quality for a designated use be maintained except in those instances where because of natural conditions the quality is lowered.

5. Grand River Basin Metropolitan Planning Staus.

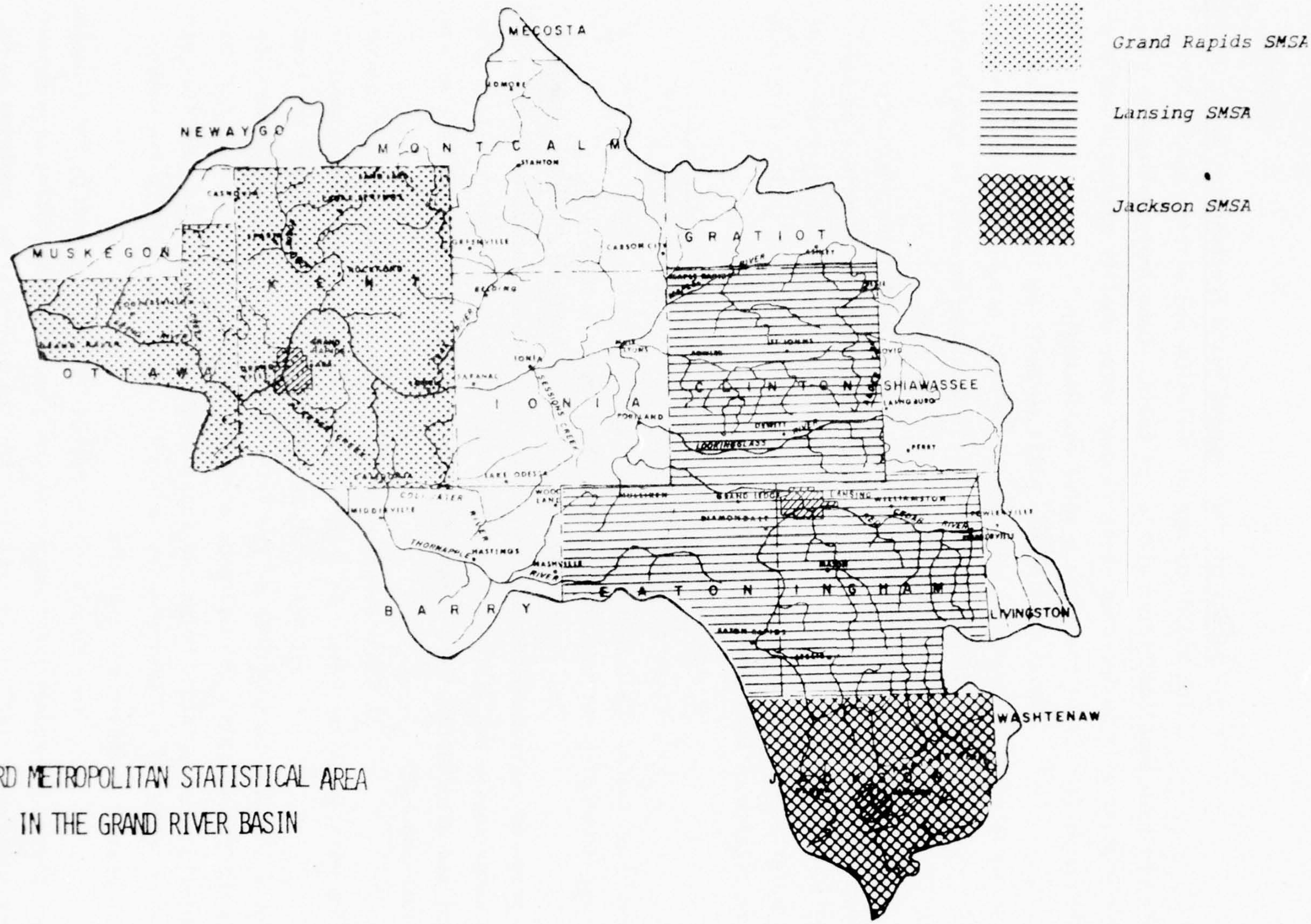
Three metropolitan areas (SMSA's) are located in the Grand River basin. Each metropolitan area has a planning commission responsible for developing metropolitan plans within their jurisdiction.

The Jackson Metropolitan Area Regional Planning Commission has prepared regional plans covering sewers and sewage treatment, storm drainage, and water supply and distribution. The plans which include metropolitan area needs and alternatives were financed partly with HUD monies and were completed in 1969 and 1970.

A HUD approved plan for the Jackson SMSA has been approved by the Michigan Water Resources Commission and submitted for EPA approval.

A regional water and wastewater management plan has been prepared for the Lansing SMSA by the Tri-County Regional Planning Commission. This HUD funded plan outlines needs and alternatives, including regional considerations for Clinton, Eaton and Ingham Counties. It will be submitted with some additions to the Environmental Protection Agency to fulfill the Federal requirement for construction grants.

Kent County (Grand Rapids SMSA) has no HUD or FHA financed sewer plan. The county has received an FHA grant for preparation of a wastewater management plan. It is expected that the plan will be completed by May 1972. The plan will include alternatives for handling and treating wastewater as well as service areas and regional approaches to wastewater management.



STANDARD METROPOLITAN STATISTICAL AREA
IN THE GRAND RIVER BASIN

(d) Summary

1. Implementing Authority. Sanitary wastes generated within the legal limits of a community become the responsibility of that community. Therefore, they are the agency involved with implementing the pollution control plan for sanitary wastes within their jurisdiction.

In some cases the township or county has accepted the responsibility for sanitary waste within a community, as shown in Table V-12. They become responsible for implementing the plan.

Except where treated at municipal wastewater treatment plants, all industries are responsible for their own wastes which are discharged to waters within the State.

2. Consideration by Local Government. The interim Water Quality Management Plan for the basin incorporates pollution control plans developed by all communities and industries proposing pollution abatement projects. Applications have been made for P.L. 660 grant funds by most of these communities.

The pollution control plan is a requirement of Act 329 of the P.A. of 1966, as amended. Such plans are a pre-requisite for State and Federal construction grants and must be approved by the Water Resources Commission before grant applications can be processed. Act 329 further requires that planning agencies with jurisdiction in the area of the applicant shall have an opportunity to review the official pollution control plan. Comments from these planning agencies are submitted with the applications.

3. Environmental Assessment. Until such time when economical techniques are developed to provide "total treatment" or to dispose of waste safely by some other means it is necessary to continue to use surface water to assimilate the major quanties of wastes within the basin. These waste discharges will have beneficial as well as adverse effects on land, air, water and other resources.

The purpose of this plan has been to abate existing pollution of surface waters in the basins and improve the quality of the water so that it can be used for other purposes. In developing the plan, it was necessary to evaluate the effect of the plan on the total environment. The plan accents the beneficial effects of waste treatment and minimizes the harmful effects.

Table V-13 identifies the possible and probable impacts which different alternatives of treatment have on the environment. Statements followed by an asterick represent possible adverse environmental effects which could occur having an irreversible or long term effect on the environment. Proper surveillance of the construction, operation and maintenance of each facility is necessary to insure that such harmful effects do not occur or are minimized.

The Michigan Department of Public Health is reviewing each proposed project to ensure that it has been designed to take into account all aspects of environmental quality protection so as to create a minimum adverse effect on the environment and will maintain surveillance of the construction, operation and maintenance of each facility in accordance with requirements of Act 98, P.A. of 1913, as amended. Coordination within the Michigan Department of Public Health ensures that each project will not cause an air or solid waste pollution problem.

Each project is reviewed under provisions of Act 329, P.A. of 1966, as amended to ensure that there are no known sources of pollution in the logical service area of the facility which are not being provided service by the project.

No indication of public objections to the plan have occurred due to environmental issues.

The implementation of this plan will have an overall beneficial environmental effect and should be assisted to the fullest extent possible.

Table V-13

Possible and Probable Beneficial and Adverse Effects of Waste Treatment Processes on the Environment

Processes of Treatment	WATER: Beneficial Effects	WATER: Adverse Effects	OTHER RESOURCES: Beneficial Effects	OTHER RESOURCES: Adverse Effects
Sludge Disposal -Incineration			Economical approach to disposal in areas where land disposal sites are expensive and difficult to obtain	
-Land Disposal (includes ash disposal resulting from incineration)		Seepage on surface water runoff can return some of the sludge contaminants to the water		May temporarily remove land from production
Land Irrigation	Removes most of the nutrients and other contaminants from surface waters Reduces algae build-ups and eutrophication in lakes Recharges the groundwater May stabilize streamflow	Mineral buildup in the groundwater will probably occur May reduce productivity of stream Evaporization losses are greater May reduce streamflow	Irrigation will provide larger crops Dependent on water quality may have potential for fish and wildlife habitat management	May obliterate or degrade large areas of fish and wildlife habitat
Lagoons		Nutrients can accumulate in lakes and reservoirs downstream	Economical approach to treatment for smaller communities can be used as an interim procedure prior to being served via interceptor to a region facility If water quality is good, may offer potential for fish and wildlife habitat management	Loss of fish and wildlife habitat
Low Flow Augmentation	Stabilizes stream flow	If used as a substitute for treatment wastes can build up in lakes and impoundments downstream Degrades the water quality standard by increasing surface water temperature, thereby changing the biotic life (ex. cold water fish to warmwater fish species)*	Benefits other uses: -Recreation -Hydro-electric power -Greater fish and wildfowl productivity The effect on fish and wildlife could be beneficial depending on the season of the year and the method of flow regulation	Maximum need of the reservoir for recreation is not always compatible with low flow augmentation The effect on fish and wildlife could be adverse depending on the season of the year and the method of flow reglation
Interceptors	Surface waters become free of pollutants resulting in waters suitable for many uses Less groundwater contamination from previously used septic system More surface waters in the upper reaches of the basin become free of disposed wastes	Water diverted from its source may dry up streams and lower the groundwater during dry conditions Siltation at stream crossing during construction may occur In rare cases it may reduce productivity of the streams where the waste discharge is removed	Better efficiency of treatment via a regional treatment plant often occurs	
General Waste Treatment	Improves the quality of the water by removing harmful contaminates Reduces algae buildup and slows down eutrophication Removes public health hazards in the streams caused from raw waste discharges Enhances the water for other uses	In rare cases if too much of the nutrients are removed it could reduce the productivity of the stream		Requires the expenditure of other resources in order to provide treatment - energy - construction material - chemicals - etc.

*Adverse environmental effects which could occur having an irreversible or long term affect on the environment.

Table V-13 (Cont'd)

Possible and Probable Beneficial and Adverse Effects of Waste Treatment Processes on the Environment

Processes of Treatment	LAND: Beneficial Effects	LAND: Adverse Effects	AIR: Beneficial Effects	AIR: Adverse Effects
Sludge Disposal				
-Incineration				Possible adverse atmospheric effects from increased vaporization
-Land disposal (includes ash disposal resulting from incineration)	Land spreading results in wastes being recycled-has fertilization and soil buildup capabilities	Aesthetic problems of land disposal may be created Possibly toxic to vegetation if sludge results from combined industrial-municipal wastes		Raw sludge-odor
Land Irrigation	Recycles the wastes Does not withdraw land from production if used for irrigating croplands	If productive land is used and crops are not produced, the process removes a large amount of land from production Limits the type of crops that can be grown		Possible adverse atmospheric effects from increased vaporization Odor problem may result although the irrigation site is isolated from developed areas
Lagoons		Requires a large amount of land per capita served		Possible odor problems occur during certain times of the year, but the lagoon is isolated from developed areas to minimize the nuisance
Low Flow Augmentation	Increases land value around reservoirs	Promotes development around reservoirs creating new waste treatment needs. Reduces land surface		
Interceptors		Withdraws or limits the use of the land		
General Waste treatment	Sometimes wastes are recycled	The facility may become an aesthetic nuisance to people living nearby	Reduces odor from polluted waters	May create occasional odors at the plant site

5. Estimated Cost to Implement State's Interim Water Quality Management Plan for the Grand River Basin.

In the period between 1970 and 1980, the total public investment needed for additional sewage treatment facilities in the Grand River Basin is estimated to amount to roughly $100 million. This estimate includes $5 million to convert the Lansing sewage treatment plant to tertiary treatment and $9.5 million to provide both additional secondary treatment and tertiary treatment at the East Lansing sewage treatment plant. An additional $50 million would be needed for sewage treatment facilities in the period between 1980 and 1985. The above estimates include the construction of new sewage treatment plants, the installation of phosphorus removal facilities, and the rehabilitation and expansion of existing treatment plants. Not included in the estimates are the cost of sewage collection systems, combined sewer overflow control facilities, and industry-operated wastewater treatment works. These items will require substantial additional investment.

(3) Advanced Waste Treatment Processes as Long-Term Alternatives for Maintaining and Enhancing Water Quality.*

(a) Introduction

Recent studies have shown the population increase in the United States to be at the rate of 1.5 percent per year. At the same time the Gross National Production is increasing at the rate of 4 percent per year. Unfortunately, our waste water production and water use are both keeping pace with our Gross National Production. Since our water supply sources are the same natural water courses in which we discharge our waste, our water resource problems are compounding at a rate close to 6 percent.

We are rapidly approaching the ultimate yield of our natural water resource. Consequently, further consideration should be given to the concept of reusing treated wastewater as a method of enhancing our overall water supply. The extent waste water effluents could be reused depends largely on the degree of treatment the waste water receives.

The water quality problems and needs associated with our nation's natural water courses have, in recent years, influenced many communities throughout the country to add advanced treatment processes to their sewage treatment facilities. The trend is continuing at least at a 6 percent rate. Several communities in Michigan, including six general areas in the Grand River basin will likely require advanced waste treatment prior to the year 2000. Two of the areas in the Grand River basin will require advanced waste treatment between now and 1980. The City of Lansing will require tertiary treatment by December, 1973.

Advanced waste treatment may be defined as treatment over and above phosphorus removal and "secondary" or standard biological treatment which removes at least 90 percent of the organic constituents as measured by the standard 5-day BOD test. Advanced waste treatment is considered necessary when the residual BOD loading from a secondary treatment will depress the dissolved oxygen level in the receiving stream below that specified by water quality standards when the flow in the receiving stream is less than or equal to the

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*The information discussed here was taken from U.S. Environmental Protection Agency data presented at its "Advanced Waste Treatment and Water Reuse Symposium" held in Cleveland, Ohio on 30 and 31 March 1971.

7-day average low flow expected to occur once in 10 years.

The advanced waste treatment processes now being widely considered include those techniques which would be used in the treatment of municipal wastewater and those that would be used in the treatment of industrial wastes. A number of these processes which may be used now or in the near future are described in the following paragraphs (pages V-132 thru V-158).

(b) Removal of Solids

1. Introduction

The removal of suspended or colloidal solids from domestic and industrial wastewater is of major importance in improving the quality of the water. Evidence of its importance is the great variety of methods and devices which have been developed for this task. The various methods may be considered in two parts; the physical aspects which relate to the equipment and the physical methods of solids-liquid separation, and the chemical aspects which involve chemical modifications to facilitate or improve the separation of solids. The principal unit processes employed for solids removal which include the more widely used processes and some newer techniques are: (1) sedimentation, (2) flotation, (3) filtration, microscreening, coagulation-flocculation, and miscellaneous processes which include: moving bed filter, ultrafiltration, magnetic separation, ultrasonic flocculation, etc.

2. Physical Processes

a. Sedimentation

The time-honored method for separation of solids involves sedimentation by gravity. In the conventional horizontal flow sedimentation tank, detention periods of 2 to 4 hours are used to enable suspended particles to settle by gravity. It is the simplest of the processes to remove solids, and it is also the least efficient. Colloidal particles settle at such a slow rate that they are not effectively removed. Some degree of short circuiting always occurs leading to lesser detention times for portions of the flow. Because of the inefficiencies of this process many attempts have been made to improve on the separation, still using gravity as the driving force.

One such improvement is the tube settler developed in this country and the Lamella separator developed in Sweden. Both processes achieve separation by causing the particles to settle only inches rather than the several feet as in the conventional settler. This is accomplished by conducting the wastewater upward thru inclined tubes or plates: the solids move toward the lower end of the tubes while the water passes out of the tops.

The tube settler has been rather widely used for separation of floc in chemically treated river water. It is also finding application for removal of solids from chemically treated wastewater. There is sufficient information to indicate that this device does separate particles, but insufficient evidence is at hand to conclude that the increased capital investment over conventional sedimentation alone is warranted.

b. Flotation

Another process which separates particles by gravity is flotation. Separation is achieved by attachment of air bubbles, which effectively reduces the specific gravity of the particles to less than that of water. Flotation has found application for clarification of a number of industrial wastes, however, the process is little used at the present time for clarification of domestic wastewater. Its widest application in wastewater treatment is for sludge thickening operations. With additional development, air flotation may find wider application to raw sewage clarification following flocculation by chemical additives.

Air flotation has some attractive potential advantages over sedimentation: 1) a more positive control over the separation rate by controlling process variables such as air/solids ratio or chemical addition; 2) a lower initial capital cost owing to higher separation rates and shorter detention times; 3) reduction of septicity and associated odors owing to aeration of feed and shorter detention times; 4) greater sludge density allowing use of smaller equipment for dewatering; and 5) multiple use of a single treatment unit for removal of heavy grit, suspended solids and oil or grease. These advantages are gained with the following disadvantages: 1) higher operation costs, and 2) greater operational skill is required. The process clearly needs additional research to define in more detail the above advantages and disadvantages.

c. Filtration

Whenever a high degree of clarification is required, then in-depth filtration after chemical treatment is the process of choice. Rapid sand filtration has been practiced for decades by water treatment plants but only recently for wastewater application. In this process, the wastewater

passes through a bed of granular media which captures the particles within the filter. When the capacity to store particles is reached, the filter is restored by backwashing. In an ideal filter for downflow operation, the media is uniformly graded from coarse to fine from top to bottom. The usual sand filter does not meet this ideal requirement, hence mixtures of media have been employed to approach the ideal filter. The most common is a two component filter of coal on top of sand. A tri-media filter contains coal, sand and garnet.

One of the difficulties with filters is that the upper layers of the bed become clogged with solids well before storage capacity is reached in the remainder of the filter. Several approaches have been taken to overcome this problem. The filter can be operated upflow in which case the flow proceeds from coarse to fine media approaching the ideal. Some filters have been designed to introduce the feed into the middle of the filter with flow in two directions.

One of the more promising techniques developed by Johns Manville is described as a moving bed filter. The object is to renew the sand bed surface either continuously or intermittently to avoid surface plugging. This process has been tested at pilot scale and a full scale installation is being made in Manville, New Jersey. Yet another approach has been proposed by the Research Triangle Institute in which a lightweight media floats to form a packed bed. Wastewater is filtered upflow. As the media becomes clogged, it is removed from the bed, washed, and then reintroduced with the wastewater. The concept is sound but feasibility remains to be tested.

d. Microscreening

Microscreening involves straining of wastewater through a woven metal fabric having openings ranging upwards from 23 microns. The screen is continuously cleaned by pressure sprays. Only larger suspended particles are removed since straining is limited to particle sizes greater than the mesh size. These devices have thus far found their greatest application in treatment of river waters. More recently, application to removal of suspended solids from secondary effluents has been tested.

Chicago's Hanover Treatment Plant has successfully operated a microstrainer to reduce suspended solids in secondary effluent to less than 5 mg/l. Since about one-half of the residual BOD of secondary effluent is attributable to the suspended solids content, removal of the solids effects a reduction of the BOD as well as suspended solids.

3. Chemical Processes (Metal Coagulants)

The colloidal components of wastewater cannot be removed by any of the physical processes described above. To remove these solids, the particles must be coagulated and flocculated to larger size before physical methods can be effective. In conventional secondary treatment the colloids are flocculated by organic polymers produced during the biological oxidation. Coagulation and flocculation can also be achieved by chemical additives.

Chemical coagulation and flocculation, were first proposed some thirty years ago but were never widely employed. Today, chemical flocculation is the essential first step in physical-chemical treatment. The use of chemical additives has gained impetus from the need to remove phosphates from wastewater. All metal coagulants now being used for phosphate removal also accomplish clarification.

A wide variety of metal coagulants are suitable for clarification (also phosphate removal). These include: aluminum salts, such as aluminum sulfate, and sodium aluminate; iron salts, such as ferric or ferrous chloride or sulfate; pickling liquor which is an iron-containing waste stream from the steel industry; and lime. Which one of the several coagulants to use in any specific instance cannot be predicted beforehand. All metal coagulants are effective and the choice of one from the many has to be made for any application. The choice for any particular application is generally based on relative dosage, the cost of the coagulant and the chemical composition of the wastewater. It is well to remember that to obtain clarification and phosphate removal in wastewater will require substantial dosages of coagulant which in turn will produce chemical sludges which must find disposal. The range of dosages for iron or aluminum salts range 100 to 300 mg/l while for lime the range is 300 to 600 mg/l or more.

In addition to being the first step in physical-chemical treatment, chemical clarification may have some other benefits in solids removal in the primary prior to biological treatment. This concept is being tested at Grand Rapids, Michigan, at full scale. Some of the advantages that may emerge from this are: decreased air requirement in activated sludge resulting from the increased solids capture in the primary, less difficult-to-filter sludge from the secondary while producing more but filterable solids in the primary. And, of course, phosphates will be removed. One of the advantages of lime is that the sludge can be calcined to recover reuseable lime. This has been demonstrated at Tahoe for lime used in secondary effluent and will be applied to lime sludge from raw sewage precipitation at Rocky River, Ohio.

One of the interesting developments of recent years has been the synthesis of a wide variety of organic polymers. Use of organic polymers or polyelectrolytes as sole coagulants or as aids to the inorganic coagulants has added a new dimension to clarification. Very low dosages of polymer may improve efficiency of solids removal, permit reduction of inorganic coagulant dosages and increase settling rates, thus allowing operation of existing equipment at higher flow rates. Dosages range from fractions of a mg/l to several mg/l. Thus, in contrast to inorganic coagulants, sludge volume is not increased. But organic polymers are not a total panacea. They do not remove phosphates, they are all expensive and their behavior for any particular application is unpredictable. The plant operator is faced with selecting a single polymer from the literally hundreds available and even then he cannot be sure that his choice will be effective all of the time. Polymer clarification of raw sewage has been tried at Cleveland's Easterly Plant and at Grand Rapids.

4. Miscellaneous Processes

A number of other processes for solids separation are in varying stages of development. One of these is ultrafiltration which is a process akin to reverse osmosis except that inorganic minerals are not removed. The process involves application of wastewater under pressure to a porous membrane. The process cannot compete economically with other solids

removal processes for treatment of large volumes of wastewater. But there are special applications for small volume filtration where ultra-filtration may have application. For example thickening of organic sludges or powdered carbon sludge has been investigated.

Another membrane process, called "cross-flow" filtration may be useful for solids separation. In this process a membrane is formed on a support and solids separation is obtained under pressures of 30-50 psi

5. Assessment for the Future

Research of the last decade has provided the consulting engineer with an arsenal of processes for removal of solids. This development comes at a time when, more than ever, better and cheaper ways of solids removal are required. Phosphate precipitation, improved clarification of raw or secondary effluent, and higher quality effluents for tertiary processes have increased the need for separation processes which are more effective and sophisticated than the simple gravity sedimentation now so widely used.

Of the processes discussed here, media filtration, microstraining and chemical coagulation and flocculation are the processes which are now being used. The other processes will be applied as this technology is improved.

(c) Removal of Organics

1. Introduction

Most liquid wastes, both domestic and industrial, contain a complement of organics which must be removed or altered before discharge. The classical approach and the method now most widely used has been biological oxidation. Decades of research have produced a great variety of processes, all dependent on biological activity, to consume organics for energy and for cell protoplasm. Biological oxidation has limitations: some organics are not degradeable, toxic materials must be avoided and low temperatures slow biological activity. Recognition of these limitations plus the need to produce increasingly higher quality effluents for discharge or for reuse, led the Advanced Wastes Treatment Research Laboratory in Cincinnati, Ohio to search for alternatives to biological treatment.

Several processes for removal of organics from both domestic and industrial waste streams are in varying stages of development. These are: (1) Granular activated carbon, (2) powdered activated carbon, (3) adsorbent resins and (4) oxidation processes.

2. Granular Activated Carbon

Activated carbon is an adsorbent medium characterized by an extensive system of internal pores which provide it with a very large surface area per unit of weight. This large area plus the variety of functional groups (acidic, basic, oxygenated, etc.) attached to the surface give activated carbon a significant adsorptive capacity for most dissolved organics in wastewater. The carbon, when exhausted, can be reused after regeneration by heating to high temperature (ca 1700^{o}F).

The method of application is primarily determined by the particle size of the carbon to be used. Granular carbon, in the mesh size range from 8 x 30 to 40 x 60, is generally contacted with the wastewater in a fixed or fluidized bed of carbon. Originally, carbon adsorption was considered as a tertiary treatment to supplement biological processes to produce a high quality produce of reuseable quality. More recently, the main thrust of research has shifted from the treatment of biological secondary effluent to treatment of clarified raw sewage. Success in the latter effort will provide the sanitary engineer an alternative to biological treatment.

One of the first large-scale applications of granular carbon to wastewater treatment was the South Tahoe Wastewater Reclamation Plant. This 7.5 mgd granular activated carbon plant treats secondary effluent after clarification by lime and mixed media filters. The carbon effectively reduces an influent BOD from 5-20 mg/l to 2-5 mg/l; COD from 20-30 mg/l to 2-10 mg/l; and color from 20-50 to less than 5 units. The average dosage of carbon to accomplish this treatment has been 300 lb/million gallons of treated wastewater. Large-scale Studies have substantially confirmed the results obtained at Tahoe. Carbon dosage, however, was found to average about 350 lbs/million gallons. Here, too, effluent quality has been good. Total COD was reduced from 47 mg/l to 9.5 mg/l; color from 30 units to 3 units.

These two large-scale studies plus bench investigations firmly established that activated carbon can produce effluents with low organic contents and at a cost that is reasonable. To make the process economic it was recognized very early that multiple use of the carbon, in contrast to the single use practiced in water treatment, was necessary. Current regeneration techniques using temperatures of 1600-1700°F plus steam have been able to recover 92-95% of the carbon. Some losses, both physical and chemical, do occur during regeneration. Attempts to regenerate carbon in situe with chemical oxidants or caustic washes have not been successful.

The manner in which the carbon is contacted with the wastewater has been the subject of considerable investigation. The wastewater can be upflow or downflow; the carbon can be static or moved continuously or in slugs; or a fluidized bed can be used. In most of these applications pressure has been used to maintain flows. Simple gravity flow contactors (using lower flow rates) have been suggested as economic. Recent estimates by Swindell-Dressler show that the gravity flow system is less expensive in spite of the smaller flow rate. Flow rates in pressure systems have ranged 6-10 gpm/ft^2 while gravity flow will range 2-4 gpm/ft^2. The cost studies indicate that activated carbon can produce good quality effluents from secondary effluents at a reasonable cost.

A more recent concept in the use of activated carbon is replacement of the biological secondary treatment process in conventional treatment. The process sequence consists of chemical clarification of raw sewage by either organic flocculants or by metal coagulants, when phosphate removal is desired, followed by carbon adsorption. To date, technical feasibility has been demonstrated only at small scale, but full-scale application will be demonstrated within the next two years.

Some impressive information has already been developed on this process which could replace biological treatment by a purely physical-chemical process. Studies of the treatment sequence (clarification-carbon) has shown the following removals are obtainable when contact time with the carbon is 24 minutes; suspended solids 93%; BOD 93%; and COD 81%. When metal coagulants are used in the clarification step, phosphate removals in excess of 90% can be obtained.

Pilot scale investigations at the Lebanon Pilot plant of the Advanced Waste Treatment Research Laboratory have shown that lime clarification followed by carbon adsorption of primary effluent can consistently produce an effluent equal or better in quality than secondary biological treatment. Over five million gallons of primary effluent were processed to produce an average effluent product containing 10 mg/l TOC and BOD with a range of 2-23 mg/l. Phosphate removals were consistently 90% or better.

Some advantages that can be cited for a physical-chemical (P-C) process are: (1) Substantially less land would be required. (2) Capital costs for conventional plants may be 30-40% greater than that for the P-C plant, and (3) P-C process should be less influenced by shock loads, low temperature and by substances which would be toxic to a biological system, (4) The plant should be easy to operate and could be readily adjusted to produce a ranging quality of effluent as desired; (5) Odor problems should be minimal, and (6) Significantly, much less sludge will need to be handled. For example, a conventional 10 mgd activated sludge plants will produce about 150,000 gpd of sludge, about 70% of which, or 105,000 gpd, is secondary sludge. The P-C plant could very well reduce the volume to about one-half of the total, depending on the flocculant used, and this sludge should be readily filterable.

A major disadvantage of the P-C process is that ammonia nitrogen will be unaffected. Substantial reductions of organic nitrogen can be expected through solids removal both by the clarification step as well as by the filtering function of the carbon beds.

The plant which will probably be the first to demonstrate the P-C process sequence is located at Rocky River, Ohio. While the original process envisions polymer flocculation, phosphate removal and clarification is being studied for possible use. The carbon adsorption plant will consist of eight pressure contactors, 25 feet high (15 feet of carbon bed) and 16 feet in diameter, and will process a peak flow of 20 mgd (nominal flow of 10 mgd). Flow rate will be 4.3 gpm/ft^2 with a peak rate of 8.6 gpm/ft^2. Carbon will be thermally regenerated at an anticipated rate of 300-500 lbs/day/million gallons. Loss on regeneration is expected to be no more than 5%. Effluent quality objectives are 15 mg/l BOD and 10 mg/l suspended solids, but actual quality may exceed these.

Preliminary studies have shown that the wastewater can be effectively clarified (and phosphate precipitated) by ferric chloride. Initial plans call for clarification, roughing sand filters and gravity-flow carbon contractors. The latter will be 15 feet deep, containing 8 x 30 mesh carbon in columns operated in parallel at 2 gpm/ft^2.

Status Summary

The technical feasibility of adsorption of organics by activated carbon has been well established. Regeneration of exhausted granular carbon can be considered to be operational. It remains for the two P-C demonstration plants discussed above to provide operational and cost information. If cost of P-C treatment is comparable to conventional biological secondary for comparable effluent quality, then increasing numbers of these plants will be used. Reliability of the effluent quality, the smaller land requirements, the freedom from toxic influences, the lack of odor nuisance in areas of population, are some of the reasons why P-C plants will find increasing use.

3. Powdered Activated Carbon

Powdered carbon has developed into a rival of granular carbon. Its finer grain size increases the kinetics of adsorption such that 90% of its adsorption equilibrium is attained in less than 10 minutes. Powdered carbon is dosed in slurry form, after which it is separated by sedimentation following polymer flocculation. Other methods of separation are being investigated. Powdered carbon has the advantage over granular in that its cost is about 1/3 as great. Unit cost and the possibility to control the dosage applied are two of the advantages over granular.

Powdered carbon can be applied to either primary or secondary effluent and is being tested on both feeds. In contrast to granular carbon regeneration, recovery of spent powdered carbon has been accomplished only in small prototype furnaces. Larger scale regeneration will have to be done before the powdered carbon process is a practical alternative to granular carbon.

4. Other Methods for Organic Removal

At the present time, powdered and granular carbon provide the reagents of choice for removal of organics. Other methods, however, are being investigated as alternatives to carbon or for specialized applications. Adsorbent synethetic resins are available and newer ones are being developed which have the ability to sorb organics without any substantial inorganic exchange capacity. At this point of development, sorbent resins are not likely to replace carbon but the search for better ones is continuing.

A variety of chemical oxidation methods have been investigated such as chlorine catalyzed by ultraviolet light, metal catalyzed photo-oxidation, and ozone. Of these, only ozone appears to be promising. Technical feasibility was established in the laboratory by Airco, Inc., which is currently constructing a 50,000 gpd plant to establish economic feasibility. Bcause of the cost of ozone itself and the rather large doses, up to 100 mg/l, required for oxidation, application is likely to be limited to treatment of low organic content feeds, such as carbon effluents which need further organic reduction. A valuable benefit of ozonation is its disinfection of the waste stream.

(d) Removal of Minerals

1. Introduction

During domestic and most industrial uses of water there is added an increment of dissolved inorganic minerals which must be removed if water quality is to be maintained. If recycle of wastewater will be practiced in the future, then almost surely methods will be required to remove inorganic salts. Soluble inorganics are even now a significant problem for many municipalities. For example, a recent survey has shown that of the 20,215 municipal water supplies in the 50 states and 5 provinces in the United States and Canada, 1066 had raw water supplies with a total dissolved solids (TDS) of 1000-3000 mg/l; there were an additional 31 supplies that had a TDS of 300-10,000 mg/l. The rising salinity of many water supplies and the increasing cost of developing alternative sources of better quality make it difficult or uneconomic in many locations to meet the U.S. Public Health Service recommended limit of 500 mg/l TDS for potable water. These

factors justify the support for research to develop inorganic removal processes.

Several processes are currently being investigated for reducing the mineral content of municipal wastewater to an acceptable level. These include: (a) ion exchange, (b) reverse osmosis, (c) distillation, (d) electrodialysis, (e) freezing and (f) electrochemical treatment. These processes are in varying stages of development and only the first four mentioned are currently being given serious consideration as practical processes for demineralization.

All demineralization processes produce a brine solution. The disposal of this brine represents a major technical problem in the development of demineralization technology. In coastal areas it may be feasible to discharge brines to the ocean. Solar evaporation in lined lagoons can be employed where climatic conditions are favorable. However, inland areas with limited potential for solar evaporation will require the development of more sophisticated techniques for brine disposal.

2. Ion Exchange

Ion exchangers are materials containing ions that can be replaced by other ions from solution. The replaceable ion carried by the exchanger is known as the counter ion. Carriers of exchangeable cations are called cation exchangers, and carriers of exchangeable anions, anion exchangers. Once all the counter ions are replaced the exchanger is exhausted and must be restored by regeneration with a solution containing the original counter ion.

Ion exchange will almost certainly be an economic process for demineralization of wastewater, if the mineral solids do not exceed 1000-1500 mg/l. This development derives from the commercial availability of new anion resins which have 1) high selectivity for chloride ion, 2) require less regenerant and rinse water, yielding a more favorable ratio of product to feed. But most important has been the discovery that these anion resins do not become "fouled" by organics - the single most important deterrent to ion exchange with the older resins. Up to 50-60% of the COD is removed from secondary effluent with no detectable loss of exchange capacity. The COD is eluted with the regenerant.

Research at the Advanced Waste Treatment Research Laboratory has confirmed that COD is removed and that fouling does not occur. Studies at the Pomona Pilot Plant facility demonstrated that an effluent containing about 50 mg/l of TDS can be produced from a feed of about 800 mg/l TDS. The bulk of the residual TDS was silica which is not removed by a weak anion resin. In practice, the product of ion exchange will be blended with good quality, but not demineralized, effluent to provide a product with, say 300-400 mg/l TDS.

Studies conducted by other research and development teams on the removal of minerals from wastewater indicate that: (1) The DeSal Process is far superior to conventional ion exchange and makes earlier estimates of cost out of date; (2) Up to 65% of the organic matter is removed and is quantitatively eluted from the resin, and (3) After one year's operation no change could be observed on the physical or chemical properties of the resin.

3. Reverse Osmosis

Reverse osmosis is a membrane process in which water is forced to flow from a solution of high salts concentration to one of lower concentration. In natural osmosis, water flows in the opposite direction. Pressures of 600-800 psi are required to obtain this reversal of flow. The earliest applications of reverse osmosis were in the fields of chemical purification and brackish water desalination. The discovery of the cellulose acetate membrane was, perhaps, the single biggest advance in the application of reverse osmosis to desalination.

Membranes are defined as imperfect barriers which "retain" or "reject" molecules of a certain minimum size and will "pass" smaller molecules. The membranes can be tailored to almost any degree of porosity. Several types of materials have been identified as having membrane forming properties suitable for reverse osmosis. Research is continuing on development of more useful membranes.

Cellulose acetate membranes developed for brackish water desalination are relatively tight (i.e. low water permeability) and can reject over 99% of most mineral species. The water flux through these membranes is very low (10 gal/day/ft^2) and are not economic for wastewater

demineralization. Moreover, in treating wastewater, the membranes become "fouled" by dissolved and colloidal organic material leading to drastic reduction in flux. These problems have led the Environmental Protection Agency to a membrane development program pointed specifically toward wastewater treatment. Most of the effort to date has been in new membrane development and in methods to control flux decline. The most attractive membranes appear to be modified cellulose acetate types. Current judgment is that the optimum membrane will reject 50-75% of the inorganics and 90% of the organics with fluxes of 50-100 gfd. At the same time substantial effort is being directed toward alleviating the fouling problem. Essentially two approaches are being taken: (a) prevention of fouling by pretreatment procedures or by changes in the hydraulics of the system and (b) cleaning methods once the membrane has become fouled. A promising method for the latter is periodic rinsing of the membrane surface with an enzyme solution.

In addition to membranes an extremely important aspect of reverse osmosis is the hardware. Current modules are of several types and configurations: (a) tubular, (b) spiral wound and (c) hollow fiber. Each of these configurations has its advantages as well as disadvantages, and at this point in development no single choice can be made. All are being investigated concurrently. A recent projection of the economics of the reverse osmosis process by Kaiser Engineers compared the configuration as follows:

	sq ft membrane / cu ft equipment	flux gpd/sf	productivity gpd/cf
Tubular	20	32	640
Spiral wound	250	32	8000
Hollow fiber (nylon)	5400	1	5400
Hollow fiber (CA)	2500	10	25000

From this comparison, it would seem that the hollow fiber configurations are superior but in practice hydraulic inadequacies may be a serious drawback.

Another approach to reverse osmosis has been entitled "dynamically formed" membranes. In this development, the membrane is formed either from the constituents of the wastewater or from small additions of a variety of additives. The advantage of these homemade membranes is that they can be destroyed and re-formed whenever the membrane becomes fouled. This work is still in the early stages of development.

Reverse osmosis has enormous potential for wastewater treatment. Theoretically, it is conceivable that most components of wastewater can be removed to a high degree in a single unit process. Typical removals that have been obtained are shown in the following table:

Typical Removals from Secondary Effluent
(CA membrane, 450 psi, 8 gfd)
% rejection

Total Organic Carbon (TOC)	90	Phosphate	94
Total Dissolved Solids (TDS)	93	Nitrate	65
Turbidity	99+	Ammonia	85
Alkalinity	90	Organic Nitrogen	86
Chloride	80-85		

The practical achievement of the above theoretical capability must await the solution of some serious problems, among which are: membrane fouling, membrane cost, greater (and therefore economic) fluxes, and reduction of operating costs. Because of the potential of this process, research on all of the problems is being pursued vigorously.

4. Distillation

Distillation is now the most commonly practiced method for obtaining fresh water from sea water. Today there are 90 million gallons per day of plants in operation or under construction in various parts of the world, and this capacity is being expanded rapidly. As everyone knows, distilled water is a common synonym for pure water, hence it is not surprising that distillation is being considered for wastewater treatment and renovation. But distillation of wastewater is substantially different from distillation of sea water. Preliminary studies have revealed that some treatment of the distillate (product) will heve to be practiced to remove volatile substances. It is also likely that the solids and organics in wastewater will pose additional problems. All of these aspects are being pursued.

5. Electrodialysis

Another membrane process for demineralization is electrodialysis, but, in contrast to reverse osmosis which uses pressure as the driving force to separate water from minerals, the energy in this case is electrical. A direct electric voltage applied across a cell containing mineralized water will cause the cations to migrate to the negative electrode and the anions to the positive electrode. If cation and anion permeable membranes are inserted between the electrodes, then mineral ions can be separated from the water. Characteristically, 40-50% of the dissolved salts can be removed in a single pass through an electrodialysis stack.

The technical feasibility of electrodialysis has been demonstrated both for brackish water desalination and wastewater demineralization. But, as with reverse osmosis, membrane fouling by wastewater solids and organics has deterred practical application. The process is being investigated at both the Lebanon, Ohio and Pamona, California pilot plants. Emphasis of the research is on controlling the membrane fouling by intensive treatment of the feed and by enzyme flushing of the membrane surfaces. The process could be economically attractive once the fouling problems can be solved.

(e) Removal of Phosphorus

1. Introduction

Phosphorus is considered by many investigators to be the key nutrient in breaking the eutrophication cycle, however, conventional secondary plants are not efficient in phosphorus removal. Phosphorus enters a plant in the highest oxidized form. But, no common biological systems reduce phosphorus; therefore, it cannot be liberated in a gaseous form as nitrogen, carbon, and sulfur are. Removal by biological means, then, is limited to cell metabolic needs and whatever excess phosphorus can be encouraged to be taken by and stored by the cells. The quantity stored above the 1% required for maximum growth is usually classified as "luxury uptake."

A few plants have reported efficient phosphorus uptake on a sustained basis, including the San Antonio Rilling Plant and the Baltimore, Maryland Plant. These results cannot be readily duplicated at other plants by manipulation of operating conditions. We have not learned enough about the phenomenon to take advantage of it. The removal of phosphorus by biological synthesis and "luxury uptake" is not a controllable process at this time.

If we are to reliably remove phosphorus from wastewaters on a sustained basis, we must choose the chemical or the chemical-biological methods. Strict chemical methods precipitate phosphorus either in the primary settler or in a tertiary clarifier. The chemical-biological method employs direct chemical dosing to the aerator of an activated sludge plant. The chemically-bound precipitated phosphorus is removed with the sludge and is not resolubilized during sludge disposal unless the pH is substantially lowered. Effluent phosphorus concentrations of 1-2 mg/l as P can be regularly achieved if the precipitation is accomplished in the primary or secondary portions of the plant. Tertiary lime clarification followed by filtration will lower the concentration to less than 0.5 mg/l.

2. Biological Phosphorus Removal

The literature indicates that several factors exert an influence on biological phosphorus removal. The rate of aeration and the aeration time have been indicated by most investigators as the most important criteria, the rate of air supply probably being the more critical of the two. Aeration rates in the order of 3 to 7 cfm/gal and detention times of 4 to 6 hours appear to be desirable.

There is some disagreement in the literature with respect to optimum concentration of mixed liquor suspended solids (MLSS). Apparently, increased uptake has been attained at both low and high MLSS from 500 mg/l up to 4300 mg/l. At the San Antonio, Texas treatment plants, the optimum appeared to be 1000 mg/l or slightly higher. It was also found that the maximum overall phosphorus removal occurred at organic loadings of 45 to 55 pounds of BOD/day/100 pounds of MLSS under aeration.

It also appears essential from the literature that a dissolved oxygen (DO) level of at least 2 mg/l should be maintained in the last half of the aeration tank to insure that phosphorus will not be released in the secondary clarifier. It is possible that a still higher DO level of 3 to 5 mg/l may be advantageous to maintain a minimum DO concentration of 1.5 mg/l in the sludge until it is through the secondary clarifier. Phosphorus leakage or resolubilization will occur in the secondary clarifier when the sludge consumes available dissolved oxygen. It has been suggested that solids detention time in final clarifiers should be less than 30 minutes.

These key design criteria and operational parameters have not been sufficiently isolated and identified to effectively predict and implement controlled phosphorus removal by the solely metabolic mechanism. As more data have been collected, an alternative chemical explanation has been advanced. Simply stated this theory indicates, especially in hard water areas, that phosphorus can be precipitated within the biological floc as calcium phosphate at the end of the aeration period, where carbon dioxide is scrubbed from the water by aeration and a substantial increase in pH occurs. This amount of precipitated calcium phosphate and the precipitation of additional phosphorus by traces of iron, aluminum, and magnesium normally present in wastewater would produce an efficient overall removal.

The calcium phosphate theory has been tested at several treatment plants with erratic results. Operating a segment of the Hyperion, California Plant according to the guidelines outlined by the theory has greatly increased the efficiency of phosphorus removal. At Baltimore, Maryland where efficient phosphorus removal occurs routinely, observations show no major increase in pH during operation. Studies at Texas City, Texas where attempts were made to deliberately force calcium phosphate precipitation by the addition of 200 mg/l of lime to the aerator have not shown efficient removal.

3. Phosphorus Removal by Mineral Addition to the Primary or Secondary

Mineral addition is out of the research stage and into the application stage. Field experience on full-scale and large demonstration

pilot plants shows that ferrous, ferric, and aluminum salts can be equally effective as phosphorus precipitants in wastewater. Plants can accomplish 80 to 90 percent phosphorus removal with a minor investment in capital equipment for chemical storage tanks, chemical pumps, and control equipment

For trickling filter plants, the chemical precipitation should be accomplished in the primary tank. Direct dosing of chemicals to the trickling filter has not proven highly effective. A small dose of polymer is needed to flocculate and settle the phosphorus which is insolubilized by the mineral addition. Subsequent passage through the trickling filter to satisfy metabolic needs serves as a polishing step. Dow Chemical has conducted several studies of iron-polymer precipitation in the primary at Midland, Lake Odessa, Grayling, and Benton Harbor, Michigan. The Environmental Protection Agency sponsored projects include Grand Rapids, Michigan (45 mgd) and Richardson, Texas (1.5 mgd).

With an activated sludge plant, it makes very little difference where the point of addition of the metal ion is. Efficient removals have been obtained when dosing raw wastewater before primary settling, after primary settling, in the aeration tank, or near the mixed liquor exit point. Physical constraints of a particular plant may favor one point of addition over another. However, the key factor in this approach is that no matter where the metal ion insolubilizes the phosphorus, the overall plant efficiency is dependent upon the ability of the biological floc to collect these dispersed precipitates and remove them from the final plant effluent. Polymer addition in the primary is not necessary for an activated sludge plant as the naturally occurring polymeric materials in the mixed liquor will serve the same purpose.

Dosages of 1.5 to 2.0, on a molar basis, of metal ion to phosphorus can produce effluents with a residual total phosphorus of 1 milligram per liter or less consistently on full-scale application. As is true with other parameters such as BOD, COD, and suspended solids, if very low residuals are desired, filtration of the effluent would be required. If commercial aluminum and iron minerals are used, the chemical cost will very from 2-5¢/1000 gallons, depending on the phosphorus con-

centration and the chemical employed. If waste pickle liquor is available for the cost of trucking only, the chemical cost may be within a suitable range.

The mineral addition process can be superimposed on the three sludge biological denitrification process to achieve efficient phosphorus, nitrogen, carbon, and suspended solids removals in one integrated treatment sequence. In this process, the recommended major point of mineral addition is to the high-rate unit with a small polish dose to the denitrification unit to precipitate residual phosphorus.

4. Lime Precipitation of Phosphorus

Dorr-Oliver's Phosphate Extraction Process (PEP) is the only commercially advertised lime precipitation process for use in the primary. In this process, a solids contact type reactor-clarifier is used instead of a conventional primary settler. Clarifier underflow solids are recycled to the raw sewage to maintain 500-2,000 mg/l of suspended solids in the reactor. The objective of the PEP process is to achieve 80% phosphorus removal in the primary, depending on the subsequent activated sludge step to increase overall removal to 90% or greater. Currently, lime precipitation is also being considered as the first step in a chemical-physical treatment sequence for raw wastewater that does not include a biological unit. Subsequent units in the sequence include lime recovery, filtration, carbon adsorption and possibly ammonia stripping.

(f) Removal of Nitrogen

1. Introduction

Municipal wastewaters have nitrogen contents in the 15-25 mg/l range in untreated and primary settled wastes; the nitrogen is divided between organic compounds, which are mostly insoluble, and ammonia. In general, we can depend on conventional biological processes to transform almost all nitrogenous components in wastewater into ammonia and biological sludge. Once this has been accomplished, we can design systems to remove

ammonia by air-stripping. Ammonia stripping at high pH in cooling towers following lime treatment is effective but cannot be used during freezing weather and may suffer from serious scale problems.

Under favorable conditions, biological processes may also oxidize ammonia to nitrates by a two-step sequence called nitrification. It would be beneficial if waste treatment plants were required to produce nitrified effluent. Ammonia nitrogen in effluents has several undesirable features: (1) Ammonia consumes dissolved oxygen in the receiving water, (2) Ammonia reacts with chlorine to form chloramines which are less effective disinfectants than free chlorine; (3) Ammonia is toxic to fish life, (4) Ammonia is corrosive to copper fittings, and (5) Ammonia increases the chlorine demand at waterworks downstream.

A nitrified effluent, free of substantial concentrations of ammonia, offers several advantages: (1) Nitrates will provide oxygen to sludge beds and prevent the formation of septic odors, (2) Nitrified effluents are more effectively and efficiently disinfected by chlorine treatment, and (3) A nitrified effluent contains less soluble organic matter than the same effluent before nitrification.

A nitrified effluent is far preferable to one containing substantial ammonia. However, ammonia and nitrate are interchangeable nitrogenous nutrients for green plants and algae, as well as bacteria. If the nitrate level is too high and is helping to stimulate undesirable aquatic growths, the effluent can be further treated by biological action to convert the nitrates to nitrogen gas. This process is called denitrification. The best developed method at this time for control of nitrogen compounds is biological oxidation to nitrates followed by denitrification with the aid of methanol.

Selective ion exchange of ammonia with lime regeneration may be practical but the process is still in the pilot stage. Several other processes are being studied including selective ion exchange of nitrate and chlorination of ammonia to liberate nitrogen gas.

2. Nitrogen Removal by Biological Suspended Growth Reactors

Success in providing a high efficiency for nitrogen removal by biological denitrification requires that the biological transformation of ammonia nitrogen to nitrate nitrogen be under good process control. Any reduced nitrogen compounds introduced into the denitrification stage will pass through the process unaltered and impair overall nitrogen removal efficiency.

Complex factors are involved in maintaining nitrification with a conventional activated sludge system. If nitrification occurs at all, it may be due only to an unintentional accident of design. A three sludge variation of the activated sludge process, developed at the Robert A. Taft Water Research Center in Cincinnati, Ohio greatly simplifies the process control problems associated with maintaining nitrification.

The three sludge system allows management of the separate biological transformations which are necessary for successful denitrification. The three sludge systems are staged in sequence, with flow passing from one stage to the next. The first stage is a high-rate sludge system, the second stage a nitrification sludge system, and the third a denitrification sludge system. The high-rate system handles the bulk of the carbonaceous removal and at this station the waste activated sludge is removed. Thus, the nitrification stage receives a predominantly ammonia nitrogen feed and an enriched culture develops because each sludge system has its own sludge recycle. This process design also has other desirable features. The high rate system protects subsequent nitrification stages from toxic chemicals. Since this is a staged system there can be no direct short circuiting of materials from the influent to the effluent. Temperature effects on the enriched culture of the nitrification stage are not as extreme as with a single sludge system which contains only a marginal population of nitrifying organisms.

Once controlled nitrification has been established, the biological denitrification process can be optimized. The nitrified effluent flows to a slowly stirred anaerobic reactor where methyl alcohol is added in proportion to the nitrate nitrogen concentration. The organisms in this

stage use the oxygen component of the nitrate radical to oxidize the organic carbon of methyl alcohol. The end products of this metabolism are elemental inert nitrogen gas and carbon dioxide, which are liberated to the atmosphere.

The stage approach to nitrification has been investigated in work at the Robert A. Taft Research Center (1) and in large pilot plant operations at the University of Notre Dame (2) and Manassas, Virginia (3). The process has also been evaluated on a 1 mgd scale at Hazel Crest, Illinois. A summation of these studies show that biological denitrification is a controllable process if the reaction is forced with an organic supplement, such as methyl alcohol. Total nitrogen in an effluent can be reliably reduced to about 2 mg/l.

3. Nitrogen Removal from Wastewaters by Column Reactors

Columnar nitrate reduction represents a second alternative to the suspended growth systems as a means of biochemically reducing the nitrate ion to elemental nitrogen. In a packed column, the cell residence time of the surface bound slime is much greater than the hydraulic detention time. This, combined with a large contact surface and short diffusion distances afforded by small media such as sand, provides an efficient system for rapid denitrification of an applied feed.

Work at the Lebanon, Ohio Plant has shown that the smaller media systems (sand to 3/4 inch diameter stone) are effective when operated downflow at surface loading rates of 7.0 gpm/ft and at actual contact times of 50 to 30 minutes. Daily backwashing is required to relieve pressure drop due to the accumulation of suspended solids in the upper portion of the column. The denitrifying slime is firmly attached to the media surface, and is not removed during the backwash operation. Greater than 90 percent nitrate reduction can be achieved within these columns at contact times of 10 minutes for sand and 30 minutes for the 3/4 inch stone. The effluent normally contains less than 2.0 mg/l of nitrate nitrogen with effluent turbidities less than 3 Jackson Turbidity Units (JTU), indicating little solids contribution from the attached organisms.

Larger media varying in size from 1 inch to 2 inch aggregate have been successfully employed to denitrify agriculture subsurface drainage at Firebaugh, California. The larger

media permits upflow operation without backwashing at the expense of longer contact times and increased effluent suspended solids. Nitrate reduction of greater than 90 percent were achieved in contact times of 1 hour for the 1 inch aggregate and 2 hours for the 2 inch aggregate at temperatures above 12 °C. The 2 inch columns have been operated continuously for over six months on agriculture subsurface drainage without the loss of efficiency or solids accumulation.

As with suspended growth denitrification, methyl is used as the supplemental organic carbon source of choice for columnar denitrification because of its low cost, biodegradability and ease of handling. Approximately 3 mg of methyl alcohol are required per mg of nitrate nitrogen removed including the requirement for deoxygenating the nitrified feed.

4. Ammonia Nitrogen Removal by Stripping with Air

Ammonia can be removed from a wastewater effluent by raising the pH to convert ammonium ion to dissolved ammonia and then contacting the effluent with a sufficient quantity of ammonia-free air. This physical process is called desorption or, more commonly, "stripping."

If the contacting is done in a packed tower, the pressure drop across the tower is about 1.0 psi or 28 inches of water. Since the volume of air required per unit volume of wastewater effluent is very high, about 400 cubic feet per gallon in a countercurrent operation, the cost for power to overcome even this relatively low pressure drop is prohibitive.

The problem of high power cost was solved by investigators at the South Lake Tahoe Public Utility District who used a slat-filled tower such as is used for cooling water to contact water and air. The pressure drop across such a device is very low, about 1/2 inch of water, so power costs are reduced to reasonable levels. Removal efficiencies as high as 90 percent were obtained in a 24-foot high tower in which

wastewater effluent and gas were contacted in a nearly counter-current fashion. On the basis of this experience, a full-scale stripping tower was constructed at South Lake Tahoe. The tower was designed to remove 90 percent of the ammonia from 3-1/2 MGD of Tahoe's renovated wastewater. The air flow is not countercurrent to the liquid but flows across the tower (cross-flow), while the wastewater drips downward through the packing.

Initial operation of Tahoe's stripping tower was in the winter and immediately revealed a limitation of ammonia stripping. When air temperature fell below $0^{\circ}C$, freezing of water occurred at the air inlets, making the tower inoperable. Also, since ammonia solubility is higher in cold water than in warmer water, more air is required to remove it (800 cubic feet per gallon at $0^{\circ}C$). The Tahoe tower was designed for 400 cubic feet per gallon; therefore, removal was much lower than 90%.

Another problem which developed at Tahoe is the formation of scale in the tower. The scale is chiefly calcium carbonate. It forms because the previously lime-treated effluent is supersaturated with respect to calcium carbonate. In the case of the tower at Tahoe, the sludge can be flushed from the tower except from inaccessible areas which cannot be reached with a water jet. A pilot scale ammonia stripping tower at the U. S. Environmental Protection Agency's Blue Plains, Washington, D.C. Pilot Plant, has had similar scaling problems, except the scale is hard and adheres to the tower fill. The causes of the differences in the nature and amount of scale in various locations have not been resolved. Studies are in progress to see if the scale can be prevented from forming, or if it can be made nonadherent.

The cost of ammonia stripping has been estimated for the South Lake Tahoe facility to be about 2.9¢ per 1000 gallons of wastewater treated. This does not include the cost of the lime and facilities to raise the pH to about 11. These costs have been charged to phosphorus removal because this is the direct objective of the lime addition. If 90% removal of ammonia nitrogen is required even in cold weather, these costs should be increased by about 50% to provide for a higher air-to-water ratio.

Ammonia stripping is feasible when the temperature is above freezing but there is danger of serious fouling by scale. The best approach for minimizing scale and its effects appears to be to use a pH of about 10.5, countercurrent operation rather than cross-flow, and an open fill to allow for easy flushing of accumulated solids.

5. Nitrogen Removal by Chemical Methods

a. Removal of Ammonia by Selective Ion Exchange

Conventional water softening ion exchange resins which are selective for calcium and magnesium do a relatively poor job of removing ammonium from dilute solutions. Total deionization by mixed bed ion exchange resins will, of course, remove ammonium ions along with other cations but this process is too costly for wastewater treatment.

Certain zeolites show unusual selectivity for the ammonium ion. A demonstration project at the Battelle Memorial Institute - Pacific Northwest Laboratories in 1969 showed that certain zeolites, including the naturally occurring mineral clinoptilolite, had a high selectivity for ammonium in natural and wastewaters. A trailer mounted demonstration plant with a capacity of 100,000 gallons per day was built as a cooperative demonstration project between the Environmental Protection Agency and Battelle-Northwest. Clarified secondary effluent is passed downward through columns containing clinoptilolite. When a column becomes loaded with ammonia, it is regenerated with limewater containing sodium chloride to speed up the rate of regeneration. The high pH of the limewater converts the ammonium ion to unionized ammonia gas in solution. The ammonia laden limewater is then pumped through a packed column through which heated air is blown to remove the ammonia.

b. Ion Exchange for Nitrate Removal

Several attempts have been made to develop selective ion-exchange processes for nitrate removal. Dow Chemical Company is presently under contract to the Environmental Protection Agency, to develop a nitrate removal process based on the use of a porous solid absorbent containing a nitrate-selective water-immiscible extractant. The process has the advantages

of liquid ion-exchange technology and the ease of operation of the granular bed resin systems.

Selective nitrate removal by ion exchange will not be feasible until new resins are synthesized with a high selectivity for nitrate over other anions present in the water. In addition, a suitable process for treating the nitrate laden regenerants must be developed.

c. Chlorination of Ammonia

Ammonia can be oxidized to nitrogen gas by chlorinating to the breakpoint with either chlorine gas or sodium hypochlorite. Four moles of chlorine or hypochlorite per mole of nitrogen gas liberated are required. Hypochlorite is more expensive than chlorine gas, but it is much safer to transport and handle. Breakpoint chlorination, of course, also disinfects the wastewater as well as oxidizing ammonia. However, the addition of 200-300 mg/l of chloride ion would not be acceptable for many inland waters.

(4) Land Disposal (Spray Irrigation) as a Long-Term Alternative for Maintaining and Enhancing Water Quality

(a) Introduction

The use of effluents from municipal sewage treatment facilities in irrigation has long been practiced. Sewage "farming" in the United States began in the late 19th Century in Wyoming, Colorado, California, Utah, and Montana. At the present time, extensive sewage farming is done in arid regions of these western States. Because water availability is critical, little attention is given to the bacteriological quality of the water supply. This practice of irrigation, on several occasions in the past, has contributed to the outbreak of diseases as contaminated vegetables and fruits were consumed. Today, U. S. Public Health Service restrictions, low levels of population infection, and curative medicine have practically eliminated disease or worm infections from food contaminated by irrigation practices in the United States. This does not mean, however, that no threat exists from this source. Consequently, communities now engaged in the planning and design of land disposal systems should provide for maximum sanitary practices to be carried out during the operation of these systems.

Several communities in Michigan including a number in the Grand River basin are now considering land disposal or spray irrigation as a method of enhancing and maintaining water quality. While water quality would be the primary benefit achieved; fish and wildlife, water oriented recreational, agricultural, and cultural-aesthetic benefits may also be derived from this method of wastewater management.

(b) The Land Disposal System

Where the treatment of sewage is to be accomplished in lagoons, a typical land disposal system may consist of six basic components: (1) a collection and transport network, (2) treatment cells (aeration lagoons), (3) storage lagoons, (4) irrigation land and facilities, (5) the soil and organisms, and (6) a drainage network. Taken together, these components form a wastewater management system. A brief discussion of each component is presented below.

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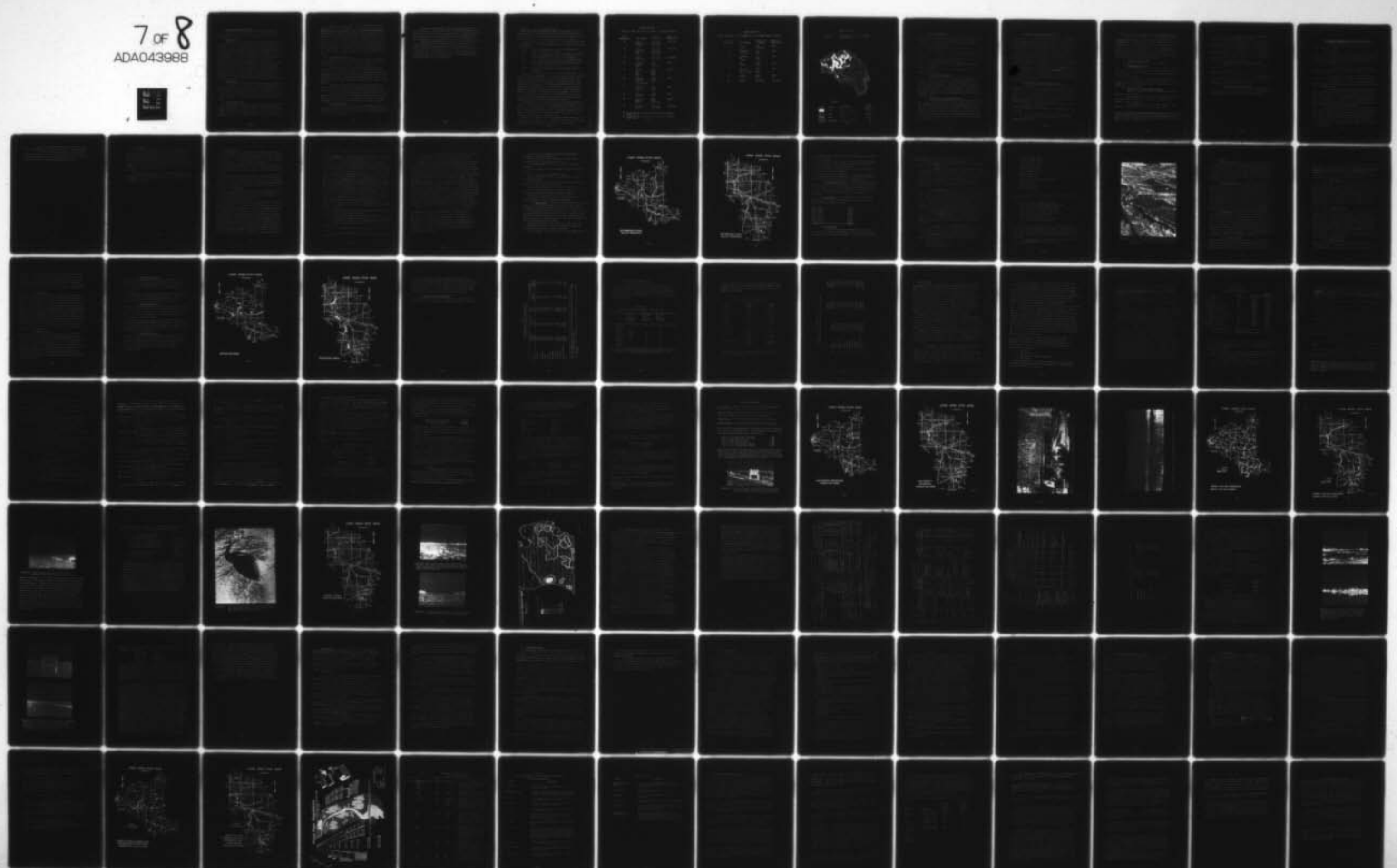

1. Collection and Transport Network

This component of the system may consist of force mains and gravity sewer lines which would be used for the collection and transportation of the wastewater to the treatment cells.

2. Treatment Cells

The raw sewage is transported and discharged to treatment cells or aeration lagoons. The treatment cells may be equipped with diffused air pipes or mechanical aerators floating on the surface of the wastewater. Well designed treatment cells having sufficient aeration capacity could reduce the biochemical oxygen demand of the wastewater 70 to 90 percent in a 3 day period. This degree of treatment would be comparable in quality to that achieved by conventional secondary treatment. Where diffused air pipes, mechanical aerators or some other method of aerating the wastewater is not provided, the time required for the biological treatment process to take place is from 20 to 30 days if not longer. Treatment cells designed to operate without the benefit of any form of mechanical aeration, generally are shallower and hence require more land than those designed to include a system of aeration. Consequently, their use is often limited to smaller communities where it becomes more economical to meet the cost of acquiring additional land than to employ aeration equipment.

3. Storage Lagoons

The provision of storage lagoons in the system provides operating flexibility so that it is not necessary to irrigate during periods of heavy rainfall or during times when the ground is frozen. The storage lagoons provide treatment through waste stabilization. After withdrawal from the storage lagoons, the treated wastewaters should be disinfected by chlorination prior to irrigation. The lagoons should be lined with clay to prevent seepage losses.

4. Lands for Irrigation

A land disposal or spray irrigation system requires large tracts of land per capita served. Consequently, the availability and cost of the required land often presents a major problem to a proposed system becoming economically justified. In addition to its availability and cost, the suitability of the soil for spray irrigation is also of primary importance.

Lands selected as irrigation disposal sites should have a good proximity to the lagoons, relatively level topography, and a suitable soil type, preferably loamy sand which is able to assimilate irrigation waters without appreciable runoff. Design criteria used to establish sizes for irrigation sites located in Michigan's lower peninsula should be based on: (1) The irrigation season being 7 or 8 months in length and (2) an average application rate of about 2-1/2 inches per week. If the irrigation sites are located adjacent to a stream, the spray irrigation should be directed in such a way that the water does not fall into the stream or onto the banks of the stream. A discussion of soils in the Grand River basin which are suitable for spray irrigation is presented on pages V-89 through V-92 herein.

5. The Soil and Organisms

The soil and organisms or aerobic soil zone, which the effluents pass through after being sprayed onto the irrigation lands, provides what could be described as the equivalent of tertiary treatment.

Nutrients are used by plants or removed by the soil, e.g., the earth serves as a phosphate sink. Viruses, which are positively charged when the pH of the wastewater is between 6 and 9, are removed by oppositely charged earth particles. The pH of most municipal wastewaters generally falls within the 6 to 9 range. Heavy metals are absorbed by organic matter and by clay particles in the soil. These metals are required by the plants as trace elements.

The aerobic soil zone has been shown through research to be an efficient and effective remover of not only pollutants that are dissolved in water, but also such pollutants as color and residual suspended solids.

It is recognized that the capacity of the soil and plants to absorb heavy metals is not infinite. The land disposal system should be designed, however, to insure that the rates of application and subsequent removal of these metals should be such that overloading of the soil will be avoided.

6. The Drainage Network

To allow for frequent or maximum use of the irrigation land, an underground drainage network consisting of tiles and wells should be installed to sufficiently drain the soil; thereby preventing it from becoming waterlogged and unfit for irrigation purposes.

Although the water quality of the effluents passing through the soil will be high, it is not desirable that this water infiltrate ground water supplies. The underground drainage network will help to prevent the effluent from reaching aquifers. Also, for agricultural production proposed, the drainage system could be used to help maintain desired moisture conditions.

After being collected in the underground drainage system, the highly treated effluent water could be discharged to nearby streams or it could be used for certain industrial purposes such as in cooling, processing, and washing operations. The overall usage of the collected effluent water would be subject to the approval of the U. S. Environmental Protection Agency including the Office of Water Programs and Water Hygiene Division and other concerned Federal, State, and local agencies.

Soil Suitability for Wastewater Spray Irrigation

Soil associations are groupings of two or more similar or dissimilar soil series occurring together naturally as combinations of soils and land units. An analysis has been made of the soil associations in the Grand River Basin to determine their suitability for wastewater spray irrigation.

Seventeen soil associations consisting of 32 soil series have been identified (Figure V-6). Each soil series within an association was rated in one of four categories.

Good: These soils have properties which are favorable and would perform very well in the rated use.

Fair: These soils have properties which are moderately favorable and would perform satisfactorily in the rated use; but they have restrictions which require moderate management.

Poor: These soils have properties which, in their natural state, are unfavorable for the rated use. These soils could give satisfactory performance if specialized site preparation and intensive management were used.

Very Poor: These soils have properties which are highly unfavorable and would not perform satisfactorily even with good management.

The ratings of soil series within each association determined the rating of the association (Table V-14). The rating of each soil series considered texture of top soil, sub soil, and sub strata; permeability; water intake rate; water holding capacity; and drainage. Since water disposal is the primary concern, soils capable of absorbing and transmitting water readily and serving as large filters for water purification are given the highest ratings. This would include deep, dry sands such as Rubicon and Grayling. These same soils would be rated low for normal agricultural irrigation.

Coarse textured soils may permit unfiltered material to travel long distances. On-site investigations are required to insure that wastewater disposal on such soils would not contaminate water supplies.

The mineral soils in associations 25 and 29 were rated poor primarily on the basis of natural drainage conditions which range from somewhat poorly drained to very poorly drained. If artificially drained and well managed, these soils would be rated fair to good. In fact where the possible contamination of groundwaters is of major concern, these soils, with controlled drainage, may be preferable to deep, dry sands.

Based on this analysis, it is estimated that the total acreage within each rating category is as follows: Good - 1,129 square miles; Fair - 1,487 square miles; Poor - 2,174 square miles; and Very Poor - 782 square miles.

Table V-14 Soil Suitability for Wastewater Spray Irrigation

Soil Association	Soil Series	Rating for Series	Rating for Association
19	Nestor	very poor	very poor
	Kawkawlin	very poor	
	Kelkirk	very poor	
20	Sims	very poor	very poor
	Kawkawlin	very poor	
	Capac	very poor	
	Iosco	very poor	
21	Wisner	very poor	very poor
	Essexville	very poor	
22	Montcalm	fair	fair
	McBride	fair	
	Peats	very poor	
25	Brevort	poor	poor 1/
	Iosco	poor	
	Sims	poor	
	Peats	poor	
26	Montcalm	good	good
	Kalkaska	good	
	Emmet (undulating)	good	
27	Montcalm	good	good
	Kalkaska	good	
	Emmet	good	
28	Rubicon	good	good
	Grayling	good	
29	Roscommon	poor	poor 2/
	AuGres	poor	
	Peats	very poor	
31	St. Clair	very poor	very poor
	Blount	very poor	

1/ If artificially drained, this Association would be rated "fair".

2/ If artificially drained, this Association would be rated "good".

Table V-14 (Cont'd) Soil Suitability for Wastewater Spray Irrigation

Soil Association	Soil Series	Rating for Series	Rating for Association
34	Miami	poor	poor
	Conover	very poor	
35	Coldwater	poor	fair
	Hillsdale	fair	
36	Hillsdale	fair	fair
	Fox	fair	
	Spinks	good	
37	Fox	fair	fair
	Oshtemo	good	
39	Fox	fair	fair
	Hillsdale	fair	
	Boyer, hilly	good	
42	Coloma	good	good
	Spinks	good	
43	Organic	very poor	very poor

Grand River Basin

Figure V-6 Suitability of Soils for Wastewater Spray Irrigation

Legend

Symbol	Rating	Soil Associations	Area In Basin (Sq. Mi.)
	Good	26, 27, 28, 42	1,129
	Fair	22, 35, 36, 37, 39	1,487
	Poor	25, 29, 34	2,174
	Very Poor	19, 20, 21, 31, 43	782

(c) Research and Development

After the land disposal system has been developed and placed into operation, studies should be conducted with respect to the system's design, operation, and performance. The data gathered could then be used in the consideration of similar systems for other communities. The studies conducted should include the following:

1. Water quality monitoring of surface and groundwaters affected by the land disposal system.

2. The evaluation of the efficiencies of the system's treatment components.

3. The evaluation of agricultural productivity, soils effects, and economic benefits of the wastewater irrigation.

4. The evaluation of the social, economic, and environmental impacts of the system.

A brief description of each of the four aspects of the study listed above is presented below:

1. Water Quality Monitoring

A water quality monitoring program of all streams and of all groundwater aquifers in the vicinity of the irrigation sites should be conducted. The quality parameters studied should include organic and inorganic chemicals, bacteriologic and virologic levels, nutrients, and physical characteristics. The study should begin prior to placing the land disposal system into operation and continue for a period of time thereafter. A determination of the before and after impacts of the system could then be made.

2. Performance of Treatment Components

The removal efficiencies of each component with respect to BOD, suspended solids, phosphorus, nitrogen compounds, heavy metals, other toxic substances, color, turbidity, virus and bacteriological removals, and other relevant parameters should be evaluated. The storage lagoons should be evaluated with respect to generation of odors and operational problems. The irrigation and subsurface drainage facilities should also be carefully evaluated with respect to physical performance and operating and maintenance costs.

3. Agricultural, Forest, and Soil Studies

Where the land disposal system is to be used to enhance the production of agricultural and forest crops, studies of its agricultural impacts should be initiated immediately and should continue for a period of years. Initial effort should be directed to identifying markets for alternative crops which could be produced, together with pilot farming operations. A five year minimum study should be required thereafter to assess the benefits and effects of wastewater irrigation on agricultural and forest production and soil conditions in full scale operations. The agricultural studies should include development, testing and the assessment of agricultural management programs including the investigation of crop markets, alternative crops, crop rotation, site and soil development, nutrient balance, the effects of toxic materials, etc. A portion of the irrigation land could be managed as a test site while the major part be developed for full scale commercial agriculture or leased to private operators for such purposes. The agricultural studies should also include an evaluation of the commercial farming operations during the five year study period. Studies should encompass crop production, quality, marketing, testing of public health aspects, economic return and impact on regional farming conditions and opportunities.

4. Social, Economic and Environmental Studies

A major aspect of the objectives of this system relates to the assessment of the social, economic, and environmental impacts of implementing a land disposal system. An on-going program of information gathering, community analysis and trends evaluation should be instituted and carried out over a five year period beginning with the initiation of construction. The specific objectives of this program of investigation should include making assessments of the following areas of concern.

a. Changes in the intensity and nature of usage of the water resources units affected by the system.

b. Changes in public attitudes toward the environmental quality conditions.

c. Impact of the system on the control of urbanization.

d. Impact of the system on job opportunities in industry, commerce, and agriculture.

(d) Recommended Minimum Guidelines on the Use of Sewage Effluents

The use of sewage effluents to irrigate crops, on several occasions in the past, caused concern in respect to the bacteriological quality of the irrigated water. Consequently, the U. S. Public Health Service has recommended guidelines to assist in the prevention and control of vector and related health problems associated with irrigation. A number of the recommended guidelines are presented below. They are considered to be the minimum guidelines that should be complied with when raw or treated sewage is used for irrigation. Local and State regulations should be followed if they are more stringent than these recommendations.

1. Irrigation with raw sewage

Raw sewage should not be used for irrigation.

2. Irrigation with effluent

a. The sewage to be used for irrigation should be treated by stabilization ponds, in series, having a minimum detention period of 20 days with a recommended detention of 30 days* or by a minimum of secondary sewage treatment and disinfection.

b. After being treated, the effluent should meet effluent standards or other requirements as established by the State or other agency having jurisdiction for water pollution control but in no case should exceed 1,000 fecal coliforms per 100 ml.

3. Precautions to be taken before irrigation

Before irrigation with effluent is carried out, the following precautions should be taken:

a. The areas to be irrigated should be clearly designated with signs warning in clear and visible letters that sewage effluent irrigation is being carried out.

b. The pipe network for this effluent irrigation should be completely disconnected from any potable water supply network.

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*The recommended detention period, 20 to 30 days, is based on the assumption that the biological treatment process will occur under natural conditions rather than under conditions where additional oxygen will be provided, e.g., through a mechanical aeration system.

c. All necessary steps should be taken to prevent mosquito or fly breeding in the area to be irrigated.

d. All necessary steps should be taken to prevent the dissemination of odors which may reach residential areas, recreation areas, or other areas in which the public is likely to be present.

e. No spray irrigation with effluent should be carried out less than 200 yards from a residential area or 50 yards from a road.

f. Ridge and furrow irrigation with effluent may be carried out if the distance to residential areas is greater than 100 yards and the distance to roads is greater than 25 yards.

4. Crop limitations for irrigation with effluent

Conditions under which irrigation with effluent may be permitted are:

a. Those crops which may be consumed raw and pasture lands should not be irrigated with sewage effluent.

b. Those crops normally eaten cooked or having an outer peel or husk which is normally removed and discarded, crops for industrial use and not used for human consumption, nursery trees and fodder crops for harvesting may be irrigated with sewage effluent.

5. Irrigation of lawns with effluent

Effluent should be used to irrigate lawns only where the lawns are closed to the public when the effluent is being applied and while the irrigated lawns remain wet from the effluent application.

(5) <u>Water Quality Recommendations for the Grand River Basin.</u>

Plan B adopts the State's Interim Water Quality Management Plan for the Grand River basin as the basic method by which State water quality standards are to be met.

Plan B recommends:

(a) That the State of Michigan's ongoing Interim Water Quality Management Plan, in effect throughout the Grand River basin, be implemented. Implementation of the plan will be in accordance with the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), administered by the U.S. Environmental Protection Agency, and will include:

<u>1</u>. Continuing improvement of the State's water quality management program with provisions for the Federal government to provide up to 50 percent of this cost.

<u>2</u>. Following the recommendations of and providing the required facilities as indicated in the basin water quality management plan.

<u>3</u>. The State and local units of government taking such actions as necessary to eliminate the problem of pollution due to storm water runoff from combined sewers.

(b) That the Federal government, on a timely basis, provide financial assistance to the State and local units of government to help implement the plan under current cost sharing arrangements. The current Federal share of the total cost of local wastewater treatment facilities is 75 percent. The estimated cost to implement the State's Interim Water Quality Management Plan for the Grand River basin from 1970 to 1975 is $50,000; from 1975 to 1980, $50,000; and from 1980 to 1985, $50,000.

(c) That Sections 402 and 404 of P.L. 92-500 regarding discharge permits be inforced. Under Section 402 of P.L. 92-500, no discharge from any point to navigable waters is allowed without a permit issued by the State, subject to review and concurrence by the Environmental Protection Agency. Section 404 of P.L. 92-500 authorizes the Corps of Engineers to issue permits for the disposal of dredged or fill material to navigable waters at specific disposal sites subject to review and concurrence of the Environmental Protection Agency.

(d) That the Michigan Water Resources Commission's existing programs to prevent and correct unlawful industrial discharges be enforced.

(e) That an applied research program costing an estimated $2,000,000, be instituted to investigate the applicability of advanced and currently experimental waste treatment processes including land disposal for the Grand River basin, to meet post 1985 water quality needs.

b. <u>Water Supply.</u>

Investigations conducted in connection with the Grand River Basin Study indicate that communities in the basin are not expected to experience any serious water supply shortages until about the year 2000. Preliminary alternative plans were developed with respect to meeting these water supply needs and are described in Appendix G, Water Supply and Stream Quality, and also in Sections III and IV herein. These plans provided for either the development of potential reservoir sites for water storage or the construction of a pipeline to obtain water from Lake Michigan or from Lake Erie to meet these needs.

Since communities in the basin are not expected to experience any serious water supply shortages within the next 10 to 15 years, Plan B includes no recommendations with respect to enhancing water supply resources in the basin to meet future needs.

c. Valley Preservation.

(1) *Introduction*. Plan B recommends a valley preserve system, to be implemented by the State of Michigan. Implementation of the valley preserve system would proceed in four steps: (1) designation; (2) zoning; (3) provision of public access; and (4) development for public use. Lands or interests in lands would be acquired only with consent of the owner.

The valley preserve program could best be implemented by passage of an Act tailored specifically to that end. At present, the only law of the State of Michigan which relates to valley preservation is Act 231 (the Natural River Act) of 1970.

Act 231 was designed to apply to rivers which could be considered to be "natural" or "wild" in some sense, specifically to rivers in the more northerly part of the State. The provisions of the Act which call for preservation of "naturalness" or "wildness" in its pure form cannot, however, appropriately be applied to the Grand River, since the river valley has already been subjected to extensive development.

Therefore, although the discussion below employs the language of Act 231 as a point of reference, short-comings in the intent and language of the Act as related to a relatively densely populated and highly developed area such as the Grand River Basin should be kept in mind.

Public Act 231 was passed by the 75th Legislature of the State of Michigan in its Regular Session of 1970 and signed by Governor Milliken, 3 December 1970. Implementation of the Act is vested in the Michigan Natural Resources Commission. Act 231 authorizes the establishment of a system of designated wild, scenic and recreational rivers; prescribes the powers and duties of the natural resources commission with respect thereto; funds necessary study and comprehensive planning for the establishment of the sytem; provides for planning, zoning and cooperation with local units of government; authorizes the protection of designated river frontage by acquisition, lease easement or other means; authorizes local units of government and the commission to establish zoning districts in which certain uses of rivers and related lands may be encouraged, regulated or prohibited; provides for limitations on uses of land and their natural resources, and on the platting of land; and provides that

assessing officers shall take cognizance of the effect of zoning on true cash value.

(2) Designation. Act 231 states that "The Commission, in the interest of the people of the State and future generations may designate a river or portion thereof, as a natural river area for the purpose of preserving and enhancing its values for water conservation, its free flowing condition and its fish, wildlife, boating, scenic, aesthetic, flood plain, ecologic, historic, and recreational values and uses. The area shall include adjoining or related lands as appropriate to the purposes of the designation. The commission shall prepare and adopt a long range comprehensive plan for designated natural river areas which shall set forth the purpose of the designation, proposed uses of lands and waters, and management measures to accomplish the purposes. State land within the designated area shall be administered and managed in accordance with the plan, and State management of fisheries, streams, waters, wildlife and boating shall take cognizance of the plan. The commission shall publicize and inform private and public landowners or agencies as to the plan and its purposes, so as to encourage their cooperation in the management and use of their land consistent with the plan, and the purposes of the designation. The commission shall cooperate with Federal agencies administering any Federal program concerning natural river areas, and with any watershed council established under Act No. 253 of the Public Acts of 1964, being Sections 323.301 to 323.320 of the Compiled Laws of 1948, when such cooperation will further the interest of the State."

Plan B recommends that the designation "recreational river" be applied to each of the following streams as described below.

1. The Grand River downstream from the mouth of the Portage River.
2. The Red Cedar River downstream from the west city limit of Williamston.
3. The Lookingglass River downstream from the west city limit of DeWitt.
4. The Maple River downstream from the east boundary of the Maple River State Game Area.
5. The Flat River downstream from the east boundary of the Langston State Game Area.
6. The Rogue River downstream from the north boundary of the Rogue River State Game Area.

7. The Thornapple River downstream from the west city limit of Nashville.

8. The Coldwater River downstream from the outlet of Jordan Lake.

The recommended valley preserve system is shown on Figure V-7.

(3) Zoning. Act 231 states that "after designation of a river or portion of a river as a natural river area and following the preparation of the long-range comprehensive plan, the commission may determine that the uses of land along the river, except within the limits of an incorporated municipality, shall be controlled by zoning contributing to accomplishment of the purpose of this act and the natural river plan. County and township governments are encouraged to establish these zoning controls and such additional controls as may be appropriate, including but not limited to building and subdivision controls. The Commission may provide advisory, planning and cooperative assistance in the drafting of ordinances to establish such controls. If the local unit does not, within one year after notice from the commission, have in full force and effect a zoning ordinance or iterim zoning ordance........., the commission, on its own motion, may promulgate a zoning rule..... . A zoning rule may also be promulgated if the commission finds that an adopted or existing zoning ordinance fails to meet adequately guidelines consistent with this act as provided by the commission and transmitted to the local units concerned, does not take full cognizance of the purposes and objectives of this act or is not in accord with the purposes of designation of the river as established by the commission."

The Act provides that " A zoning ordinance adopted by a local unit of government or a zoning rule promulgated by the commission shall provide for the protection of the river and its related land resources consistent with the preservation and enhancement of their values ..... . The ordinance or rule shall protect the interest of the people of the state as a whole. It shall take cognizance of the characteristics of the land and water concerned, surrounding development and existing uses and provide for conservation of soil, water, stream bed and banks, flood plains and adjoining uplands."

Under Plan B, the following counties and townships would be encouraged to establish zoning controls:

Barry County (Carlton, Castleton, Hastings, Irving, Rutland, Thornapple, Woodland, and Yankee Springs townships)

Clinton County (Dewitt, Eagle, Essex, Lebanon, and Watertown townships)

Eaton County (Delta, Eaton Rapids Hamlin, Oneida, and Windsor townships)

Gratiot County (Fulton and Washington townships)

Ingham County (Aurelius, Delhi, Lansing, Meridian, Onondaga, and Williamston townships)

Ionia County (Berlin, Boston, Danby, Easton, Ionia, Keene, Lyons, North Plains, Otisco, and Portland townships)

Jackson County (Blackman, Rives, and Tompkins townships)

Kent County (Ada, Algoma, Bowne, Caledonia, Cannon, Cascade, Lowell, Plainfield, Sparta, Tyrone, and Vergennes townships)

Montcalm County (Eureka, Montcalm, and Pine townships)

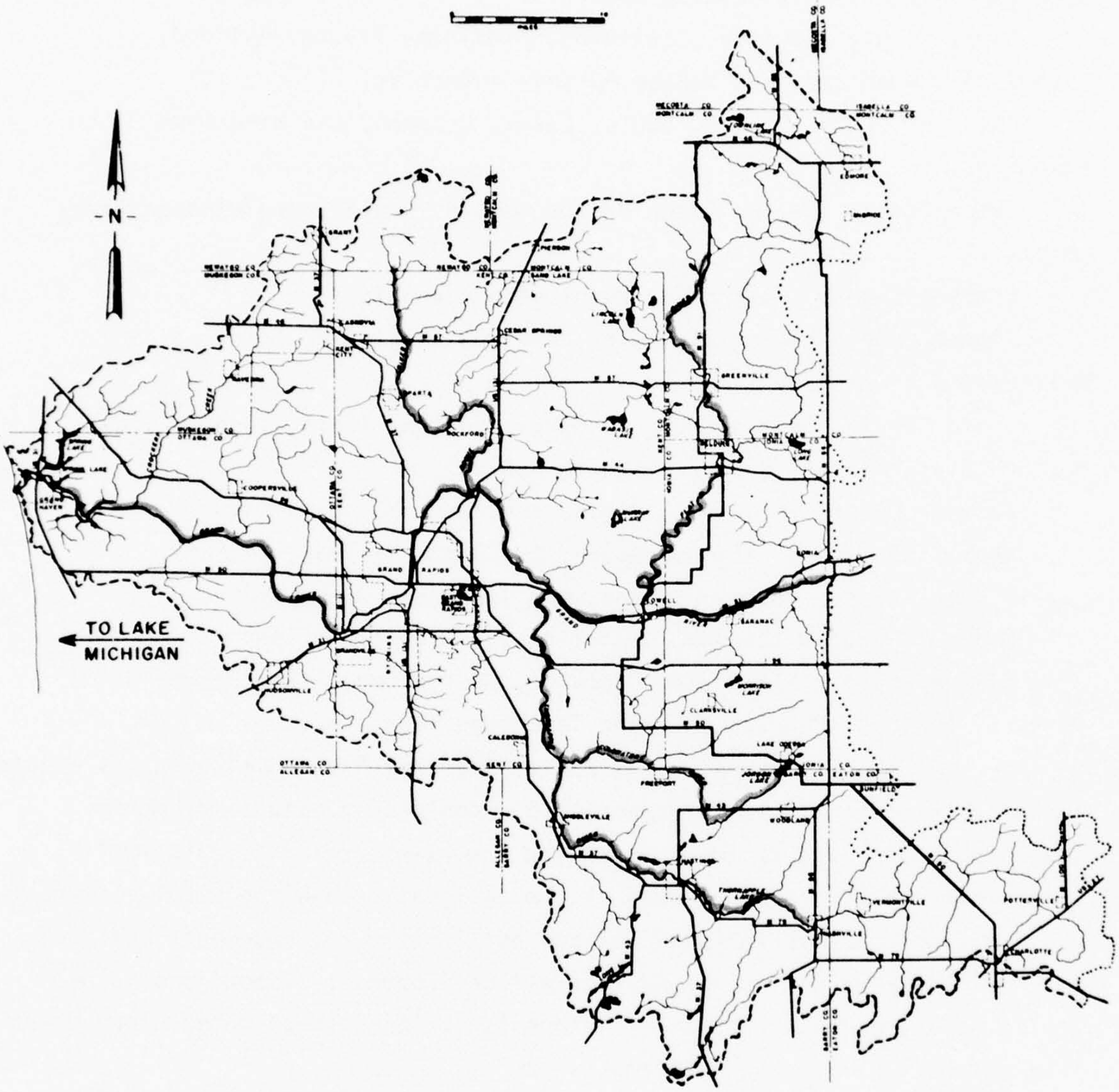
Ottawa County (Allendale, Crockery, Georgetown, Grand Haven, Polkton, Robinson, Spring Lake and Tallmadge townships).

(4) Public Access. Act 231 states that "the Commission may acquire lands or interests in lands adjacent to a designated natural river for the purpose of maintaining or improving the river and its environment in conformance with the purposes of the designation and the plan. Interests which may be acquired include, but are not limited to, easements designed to provide for preservation and to limit development, without providing public access and use. Lands or interests in lands shall be acquired under this act only with consent of the owner."

This Act also states that "the Commission may enter into a lease or agreement with any person or political subdivision to administer all or part of their lands in a natural river area."

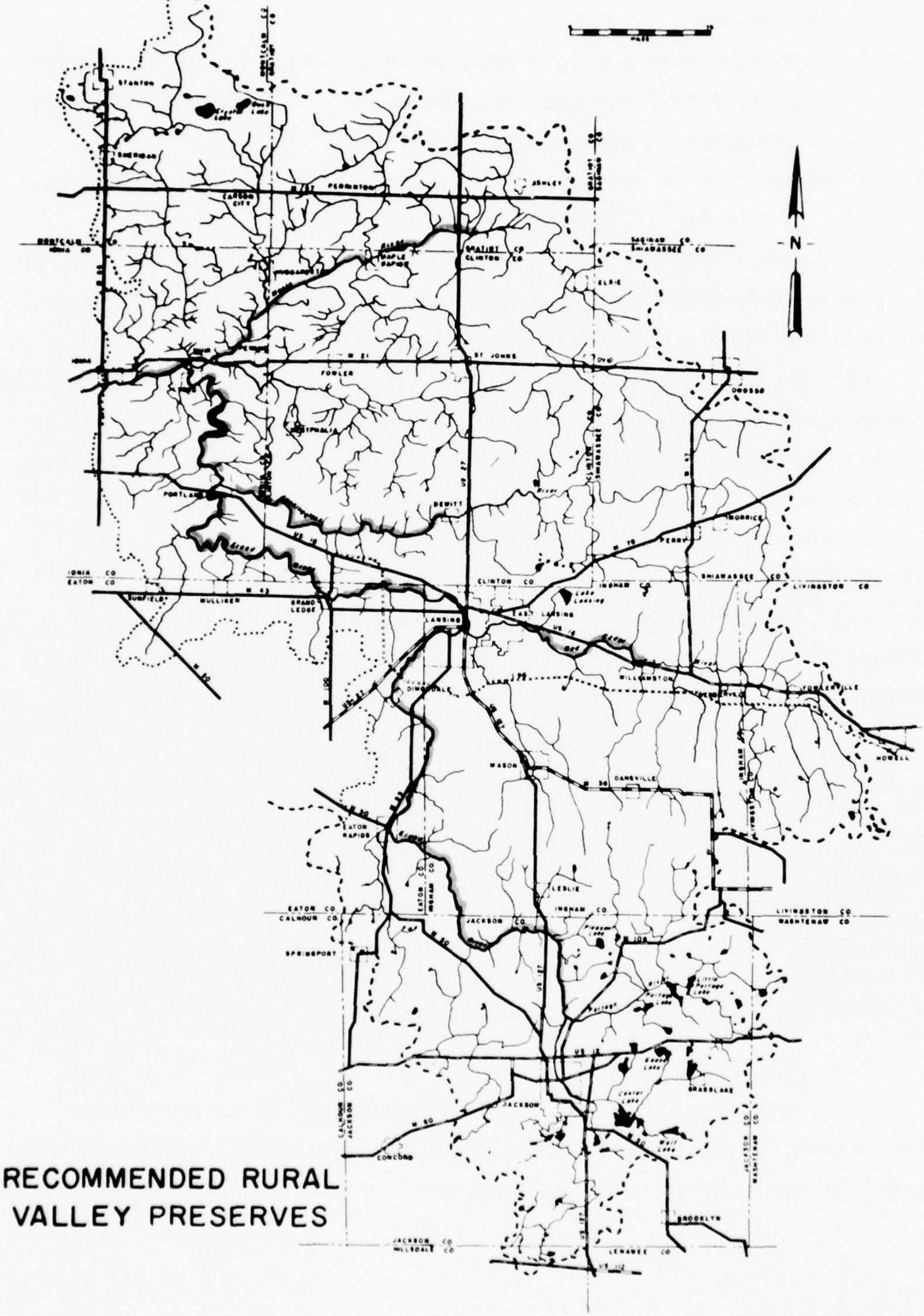
Since the length of river and tributaries to be designated under the

LOWER GRAND RIVER BASIN



RECOMMENDED RURAL
VALLEY PRESERVES

UPPER GRAND RIVER BASIN



RECOMMENDED RURAL
VALLEY PRESERVES

Act is 450 miles, there are 900 miles of river frontage (both banks) along the designated streams.

Plan B recommends that public access be provided on 450 miles of river frontage in the years 1975 through 1984 inclusive at the rate of 45 miles (or 10% of the program) in each of the 10 years.

The estimated cost of the public access program is $2,250,000 per year for 10 years, or a total of $22,500,000.

The cost, when converted to present worth (1971), would be $14,447,000. The cost, when converted to an average annual equivalent basis (100-year project life amortized at 4-7/8%), would be $710,000 per year.

(5) Development for Public Use. Act 231 states that "The commission may expend funds for works designed to preserve and enhance the values and uses of a natural river area and for construction, management, maintenance and administration of facilities in a natural river area conforming to the purposes of the designation, when the funds are so appropriated by the legislature."

(6) Accessibility. It is estimated that 777,868 persons (1970 population) would live within five miles of the valley preserve system. The distribution by county is as follows:

Barry County	20,655
Clinton County	16,757
Eaton County	39,919
Gratiot County	2,930
Ingham County	233,448
Ionia County	36,424
Jackson County	21,537
Kent County	333,331
Montcalm County	12,399
Ottawa County	60,468
Total	777,868

(7) Values and uses.

(a) Fish. Plan B proposes implementation of the valley preserve system in concert with enhancement of stream water quality through attainment of State water quality standards. It also proposes an extensive

fisheries management program in the Grand River basin. All three proposals must be implemented in unison in order to maximize benefits.

(b) Wildlife. The valley preserve would provide both wildlife habitat and hunting opportunities.

(c) Boating. Boating on the Grand River and tributaries would be encouraged by the public access provided by the valley preserves. Little or no motorboating or sailboating would be provided, but canoeing and row-boating would be activities well suited to stream waters. In particular, canoeing should be encouraged in the Basin, in part in order to reduce pressure on trout streams such as the Au Sable further north, which is currently heavily canoed. Estimates of boating benefits appear in sub-section (9).

(d) General Recreation. The valley preserves are designed for low-key extensive recreation, rather than for high-key intensive recreation. Little of the land would be developed, so that activities such as (particularly) camping and (to a lesser extent) picknicking would tend to be located on the recreation nodes rather than on the interconnecting valley preserves. Activities compatible with the valley preserves would include: (1) fishing; (2) hunting; (3) boating; (4) canoeing; (5) hiking; (6) horseback riding; (7) winter sports such as sledding and toboganning; and (8) bird watching, berry picking, mushroom hunting, nut gathering, and related activities.

(e) Flood Damage Reduction. The zoning provision of Act 231 could eliminate the possibility of an increase in rural flood damages subsequent to 1974. It is estimated that the program of acquisition would reduce rural flood damages by 25 percent between the end of 1974 and the end of 1984.

(f) Forestry. Forestry programs as described on pages V-282 and V-283, will also contribute to recreation, wildlife habitat, and environmental needs in areas that would be developed as valley preserves.

(8) Municipalities. Sixteen cities and several villages have river frontage which could be integrated into the valley preserve system through municipal initiative. The sixteen cities are presented below:

Belding (Ionia County)
East Lansing (Ingham County)
Eaton Rapids (Eaton County)

Ferrysburg (Ottawa County)

Grand Haven (Ottawa County)

Grand Ledge (Eaton County)

Grand Rapids (Kent County)

Grandville (Kent County)

Greenville (Montcalm County)

Hastings (Barry County)

Ionia (Ionia County)

Lansing (Clinton, Eaton and Ingham Counties)

Lowell (Kent County)

Rockford (Kent County)

Walker (Kent County)

Wyoming (Kent County)

The several villages which could be integrated into the valley preserve system include the following:

Diamondale (Windsor Township; Eaton County)

Freeport (Carlton and Irving Townships; Barry County)

Lyons (Ionia and Lyons Townships; Ionia County)

Maple Rapids (Essex Township; Clinton County)

Middleville (Thornapple Township; Barry County)

Muir (Lyons Township; Ionia County)

Portland (Portland Township; Ionia County)

Saranac (Boston Township; Ionia County)

If the above municipalities were to pursue a program of acquisition comparable to the program recommended for rural areas (in combination with an effective municipal flood plain zoning ordinance), it is estimated that they could achieve a net reduction of 25 percent in urban flood damages by the end of 1984.

(9) Federal Assistance. Act 231 states that "The Commission may administer financial programs for natural river areas."

Figure V-8. Reaches of the Grand River and tributaries, if developed as valley preserves, would enhance recreation, wildlife habitat, reduce flood damages and contribute to environmental needs.

d. Recreation.

(1) Plan B for Recreation. Plan B for recreation is centered on the establishment of a valley preserve system and the acquisition and development of nine recreation areas placed at strategic locations along the valley preserve system. The valley preserve system is proposed to extend along the main stem of the Grand River from its mouth on Lake Michigan to the vicinity of Jackson. It also includes portions of the major tributaries extending upstream from their confluences with the Grand River. This system comprises about 450 miles of floodplains.

(2) Valley Preserve System. The valley preserve system is being proposed to provide control of use of floodplains through zoning. Of the total 450 miles of stream valley on which such restrictions are being proposed, about 45 miles would be acquired in fee simple, and use easements would be acquired on an additional 200 miles. It is estimated that the lands acquired in fee would be about 4,500 acres; easements would be obtained on an additional 20,000 acres. These areas would be used for relatively low-density recreational use such as boat and canoe access points to the streams, and hiking, sightseeing, and nature walks. These areas could open up an estimated 3,200 acres of water for boating and canoeing. It is estimated that an additional 300,000 recreation days of opportunity could be obtained through this system.

(3) Recreation Areas. Nine recreation areas would be developed in conjunction with the valley preserve system to accommodate much of the demand for recreational opportunities for camping, picnicking, sightseeing, nature study, and hiking. Boating and canoeing opportunities would be available on the existing waters of the Grand River and its tributaries adjacent to these areas. Since the quality of water in most of the Grand River and its tributaries are scheduled to permit partial body contact only under the new State Water Quality Standards, opportunities for swimming would have to be provided by the construction of impoundments on suitable tributary streams or swimming pools. The nine nodes are shown on Figure V-9.

(a) Portland - Area No. 1

This proposed area is located along the Grand River beginning at the upper end of the Portland Game area at the Ionia-Clinton County line, and extending upstream to the city limits of Grand Ledge in Eaton County. It would contain about 2,700 acres of which an estimated 200 acres are river

water surface. This area could provide recreational opportunities for camping, picnicking, canoeing, boating, and the related activities of sightseeing, nature study, hiking, hunting and fishing. The proposed quality standards for the water in this segment of the river would not accommodate swimming. At the optimal level of development, it could provide about 670,000 recreation days of opportunity for people in and around the Lansing area.

(b) Muir - Area No.2

This recreation area is located along the lower end of Fish Creek and on the Maple River, beginning at the lower end of the Maple River State Game area and extending downstream to the Village of Muir. It would contain about 3,000 acres of which about 200 acres would be river surface. This area could provide opportunities for camping, picnicking, sightseeing, nature study, hiking, limited boating and canoeing, hunting, and fishing. The proposed quality standards for the water in this segment of the river would not accommodate swimming. The area could ultimately accommodate an estimated 650,000 recreation days of activity primarily for people living in Lansing and north and west of that city.

(c) Sandstone - Area No.3

Site No. 3 is located on Sandstone Creek in Tompkins and Sandstone Townships, Jackson County. It would begin at a point about one and one-half miles below the Village of Minard and continue upstream for a distance of about seven miles. This area would contain about 4,500 acres of which 100 acres would be water. The area could support camping, picnicking, sightseeing, nature study, hiking, and hunting. Opportunities for canoeing, boating, and fishing would be very limited. No opportunities exist for swimming, although one or two small sites appear to have development potential for small impoundments. It is estimated that this area could provide opportunities for nearly 1.1 million recreation days for people from the Jackson, Lansing, Detroit, and intervening areas.

(d) Lowell - Area No.4

This proposed recreation area lies along the Flat River in Vergennes Township, Kent County. It would begin at a point about one and one-half miles above the Village of Lowell and extend upstream between three and

four miles. The area lies across the river from the Lowell State Game Area and would contain 1,500 acres of which about 200 acres are river surface. This area could provide opportunities for swimming, camping, picnicking, sightseeing, nature study, hiking, fishing, and hunting. Canoeing and limited boating would also be available. About one-half million recreation days of opportunity could be made available for people from the Grand Rapids and Ionia areas.

(e) Ionia - Area No.5

This proposed area would be an expansion of the existing Ionia Recreation area and would be located both upstream and downstream from the present area in Ionia County. The upstream segment would begin at the upstream side of the Ionia Recreation Area and include the entire width of the Grand River valley up to State Route 66. The downstream segment would extend from the lower boundary of the Ionia Recreation Area and would include the entire river valley to the Village of Saranac. The total area would include about 2,000 acres of which an estimated 200 acres would be river-water surface. This area could provide opportunities for camping, picnicking, sightseeing, nature study, hiking, fishing, and hunting. Some canoeing and boating would be available. Swimming facilities are being developed on the existing Ionia Recreation Area. This area would serve Lansing, Grand Rapids, and other cities in the immediate area. It could supply more than one-half million recreation days of opportunities.

(f) Rockford - Area No.6

This site is located on the Rogue River above State Highway 131 west of Rockford and would be located chiefly in Algoma Township, Kent County, The area would begin about two miles upstream from the new State Highway 131 bridge and would extend upstream about four miles. The area would comprise about 1,500 acres of which about 100 acres would be water surface. This area could provide a limited range of recreational opportunities but canoeing and boating would be minimal. There would be little or no opportunity for swimming. It is estimated that annual visitation would approach 470,000 recreation days. This area would service the Grand Rapids and surrounding area.

(g) Diamondale - area No. 7

This small area is located along the Grand River between Dimondale and the lower end of Columbia Creek upstream from Lansing. It would include about six miles of the Grand River Valley and nearly two miles of Columbia Creek. The area would include about 700 acres of land with about 100 acres of water.

This area could provide a limited range of recreational activities including camping, picnicking, and some hiking, and nature study. It is estimated that the annual visitation could reach about 150,000 recreation days annually. The area could service the Lansing and Jackson areas.

(h) Plainfield - Area No. 8

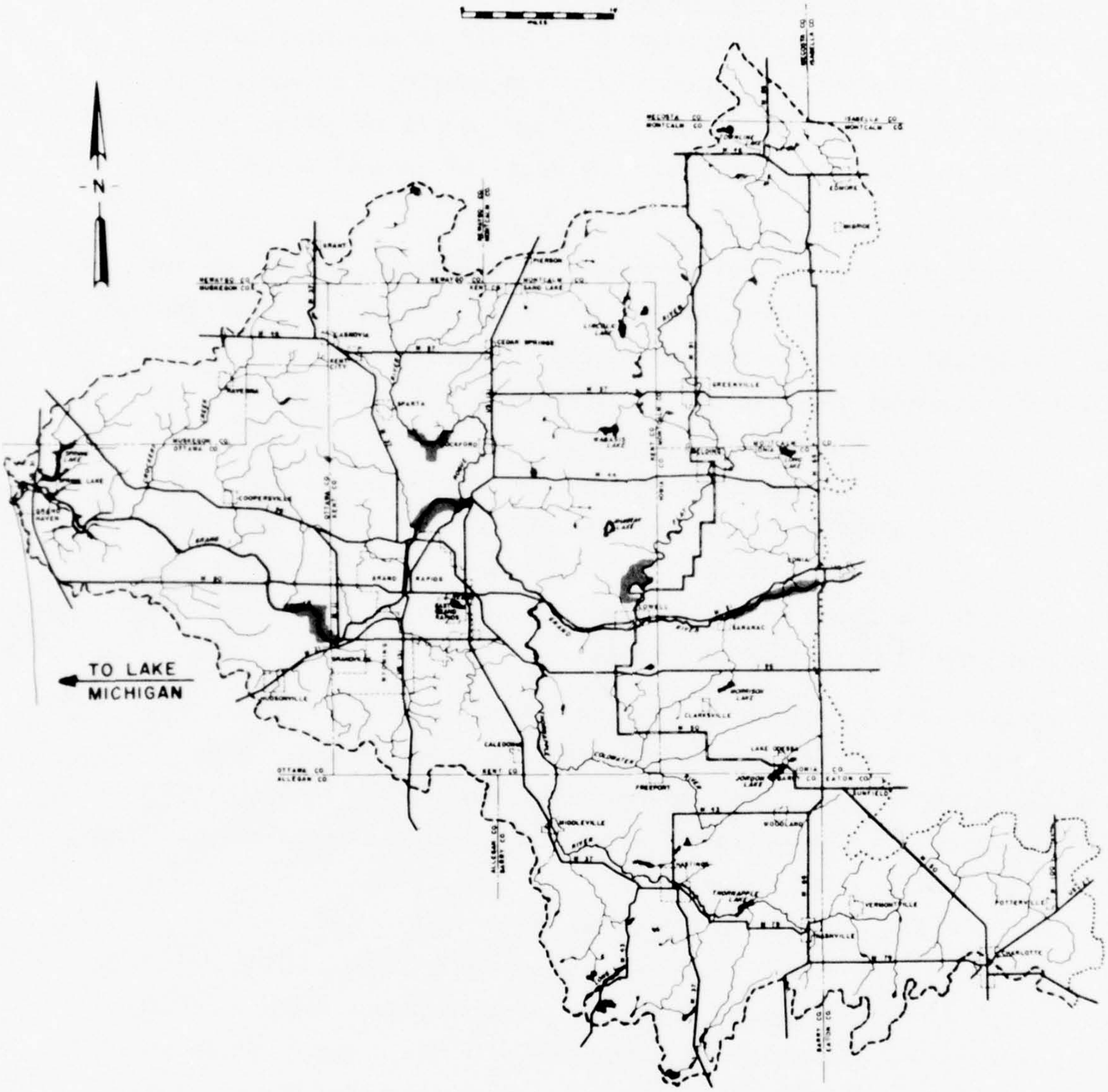
This area would be located upstream from the I-96 Highway bridge and would extend to the Plainfield bridge over the Grand River in Plainfield Township, Kent County. It would include all of the floodplain, along about six miles of the river, and would comprise about 2,000 acres of which about 300 acres would be river-water surface.

This area would be developed to provide a broad range of recreational activities including swimming, picnicking, field athletics, nature studying, sightseeing, hiking and some boating, and canoeing. It is estimated that the visitation to water-oriented recreation activities would amount to about 646,000 recreation days annually.

(i) Grandville - Area No. 9

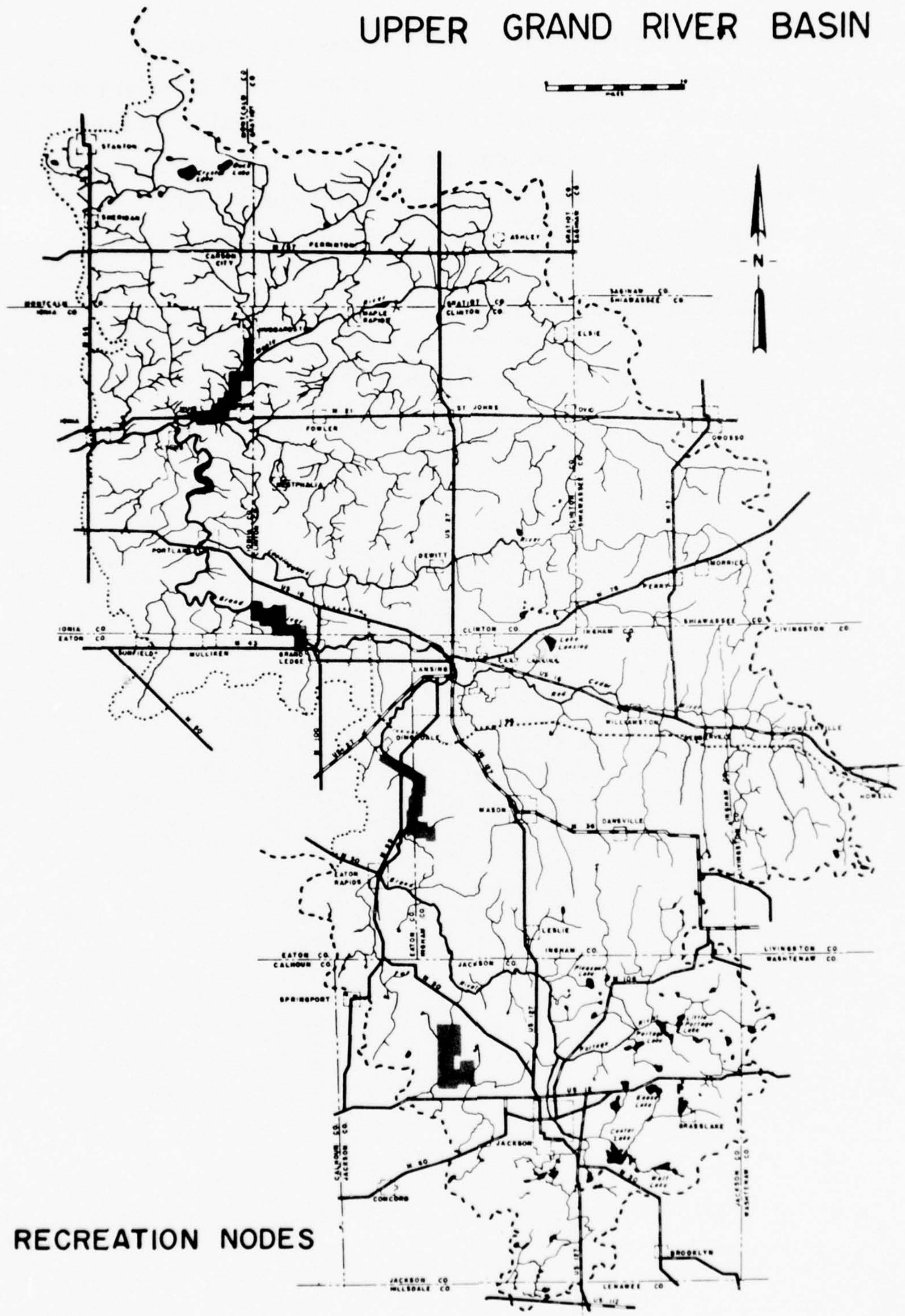
This site lies along the Grand River downstream from Grandville and would include the floodplain and adjacent land from the State Route 11 bridge downstream to the confluence of Sand Creek with the Grand River in Kent County. It would include nearly seven miles of the Grand River. The total would comprise about 2,000 acres of which about 300 acres are river-water surface.

LOWER GRAND RIVER BASIN



RECREATION NODES

UPPER GRAND RIVER BASIN



RECREATION NODES

Figure V-9

This area could support a fairly wide range of recreation activities including picnicking, field athletics, hiking, nature studying, sightseeing, some boating and canoeing. Since the Grand River at this point is scheduled only for partial body contact, there appears to be little opportunity for Swimming unless pools are provided. The area could support about 500,000 recreation days of opportunity in the water-oriented activities.

(4) Summary of Recreation Development

If the proposed valley preserve system and the related recreation areas were developed, land and water would be involved as indicated on Table V-15.

Table V-15

Estimated Total Acres and Developed Acres
of Land for Each Recreation Area (Node)

Acre	Approximate Total Acreage	Estimated Acres of Water	Acres of Land	Acres of Developed Land	
				Initial	Ultimate
Portland	2,700	200	2,500	86	251
Muir	3,000	200	2,800	92	269
Sandstone	4,600	100	4,500	153	454
Lowell	1,500	200	1,300	69	208
Ionia	2,000	250	1,750	81	234
Rockford	1,500	100	1,400	53	158
Diamondale	700	100	600	22	65
Plainfield	2,000	300	1,700	54*	159*
Grandville	2,100	300	1,800	52*	146*
SUB-TOTAL	20,100	1,750	18,350	662	1,944
Valley Preserves	4,500	3,200	4,500	32	32
TOTAL	24,600	4,950	22,850	694	1,976

*These areas should be developed to include sufficient playfields to serve Grand Rapids and other nearby urban centers.

**The 3200 acres of water estimated to be in the valley preserve system is not included in this total.

(5) Summary of Basin Needs Satisfied.

Total needs for developed land in the basin in 1985 amounts to 161 acres for swimming, 355 acres for boat launching and parking, 682 acres for camping, 677 acres for picnicking, 447 acres for parking, and 56,000 acres of water surface. Plan B would accommodate only a portion of the total 1985 needs as shown in the following table. The percent of needs satisfied is compared to Plan A.

Table V-16

Summary of Recreation Needs Met by Alternative Plans.

Activity	Proposed Initial Development IN Plan B (Acres)	% of 1985 Needs Satisfied by Plan B	% of 1985 Needs Satisfied by Plan A
Swimming	3	2	59
Boating & Water Skiing	4,950*	9	42
Camping	278	41	71
Picnicking	299	44	73
Boat Parking	55	15	30
General Parking	59	13	56

*This acreage does not represent new water area; it represents intensification of the of existing water surface on streams.

If the acreages included in the Plan B valley preserve system and the recreation nodes are properly developed, visitation for water oriented recreation activities could be expected to exceed 5.5 million as indicated in Table V-17 below.

Table V-17

ESTIMATED VISITATION FOR EACH RECREATION NODE

(IN RECREATION DAYS)

NAME	INITIAL	ULTIMATE
Portland	241,000	666,000
Muir	235,000	650,000
Sandstone	372,000	1,088,000
Lowell	193,000	531,000
Ionia	206,000	545,000
Rockford	160,000	468,000
Diamondale	50,000	150,000
Plainfield	243,000	646,000
Grandville	194,000	500,000
SUB-TOTAL	1,894,000	5,244,000
VALLEY PRESERVES	300,000	300,000
TOTAL	2,194,000	5,544,000

Average annual equivalent benefits and costs were computed for each of the recreation nodes and the valley preserve system. Computations were based on a discount rate of 4 7/8 percent for a period of 100 years.

Table V-18

Estimated Average Annual Equivalent Benefits and Costs

No.	Area	Costs	Average Annual Equivalent Benefits	Average Annual Equivalent Costs
1.	Portland	$5,170,000	$387,000	$331,000
2.	Muir	5,933,000	377,000	331,000
3.	Sandstone	8,861,000	632,000	688,000
4.	Lowell	5,245,000	354,000	313,000
5.	Ionia	5,045,000	364,000	303,000
6.	Rockford	3,734,000	272,000	237,000
7.	Diamondale	1,787,000	87,000	81,000
8.	Plainfield	6,584,000	431,000	413,000
9.	Grandville	5,857,000	334,000	360,000
	SUB-TOTAL	$48.216,000	$3,328,000	$3,084,000
	Valley Preserves	22,500,000	172,000	579,000
	TOTAL	$70,716,000	$3,410,000	$3,663,000

e. Fish and Wildlife

(1) Introduction. Historically, the funds for fish and wildlife surveys and management programs have been derived from fishing and hunting license fees. Consequently, the major thrust has been toward the provision of hunting and fishing opportunity. Nevertheless, many non-game forms of fish and wildlife and their habitat as well as the non-consumptive user (non-hunter or non-fisherman) have benefited. The fish and wildlife section of Plan B recognizes and intends to give equal consideration to all forms of life, both game and non-game, as well as to their environment. Although we have not projected non-consumptive user demands we recognize the very great importance of providing to all persons the opportunity to enjoy nature. To that end we have identified wherever practicable the benefits accruing to the non-consumptive users from the various programs discussed in this report.

The purpose of this portion of Plan B is to present a general evaluation of the present condition of the Basin's fish and wildlife resources and to analyze the effect on these resources and their potential use under Plan B, which emphasizes the preservation of corridors of open-space (valley preserves) along river and streams, and various other means of protecting, enhancing, and preserving the environment for the use and enjoyment by the public in perpetuity.

The Fish and Wildlife Appendix (K) found that under Plan A, the proposed reservoirs would have provided substantial fish and wildlife benefits in the form of user-days for both the fisherman and the hunter. In addition the nonconsumptive user such as the nature lover, bird watcher, wildlife photographer, and so on would have derived benefits at least double those of the sportsman.

(2) Fish

(a) Introduction. The Basin supports an important and varied sport fishery. The reservoir, lake, and pond fisheries provide panfish, bass, walleye and perch. The stream fishery is more varied. It ranges from the tolerant warmwater species such as catfish, perch, and sunfish to the coldwater species such as brook trout, smallmouth bass, and the anadromous fishes. During the preparation of the original report, the State was just embarking on an anadromous fish management program. This program is becoming increasingly important.

The two major deterrents to a successful and sustained sport fishery in the Basin are water quality and obstructions such as the numerous dams.

(b) Fisheries Management. The Michigan Department of Natural Resources should continue to emphasize their on-going programs of fisheries management. Increased benefits beyond those projected will be provided through expansion of the lake and stream reclamation programs which will be possible when planting stocks are available from the proposed new warmwater and trout hatcheries. Scheduled improvements in water quality will increase the supply of higher quality fish populations in many reaches of the Basin's rivers.

The Grand River and several of its tributaries have potential for management for smallmouth bass. This high-value sport fish is present in several reaches of river in the basin and will increase in significant reaches as water-quality objectives are attained. The greatest potential is in the main-stem upstream from Ionia, in the Red Cedar River, Flat River, and Thornapple and Coldwater Rivers. A key factor in management for smallmouth bass is the removal of dams, which will restore free-flowing river habitat to the formerly impounded areas. An extensive survey of the river bottom soil characteristics has identified quality gravel and rubble as the bottom type throughout significant portions of the above mentioned reaches of the river. This factor, coupled with good river-flow characteristics, provides excellent habitat for smallmouth bass and other valued sport fishes.

The Grand River Basin has several excellent small trout streams in the central and lower segments. The area of trout stream tributaries is generally from Fish Creek (tributary to the Maple River) westward, with the more important streams on the north side of the Grand River. The significant trout streams are:

1. Fish Creek
2. Prairie Creek
3. Rogue River and several tributaries
4. Sand Creek

Intensive management through control of competing rough fish populations will enhance these fisheries and extend the opportunities into the larger tributaries as water quality improves.

The anadromous fish program will provide the greatest opportunity for sport fishing development in the Grand River Basin. The principal benefits will be provided through hatchery maintained runs of coho and chinook salmon, with naturally sustained populations of steelhead as an additional opportunity. A token fishery provided by a run of adult coho in the fall of 1970 demonstrated the feasibility of this management program. The present anadromous fish runs are prevented from reaching significant reaches of the Grand River and its tributaries by various dams on the mainstem and tributaries.

Only 40 miles of the mainstem is unobstructed to anadromous fish spawning migration at present. A few adult coho successfully negotiated the Grand Rapids Dam and provided a fishery below the dam at Lyons in 1970. Implementation of the dam removal and passage facilities program will open an additional 87 miles of the Grand River--to Grand Ledge, and 25 miles of the Rogue River, 40 miles of the Thornapple River, 30 miles of the Coldwater River, 40 miles of the Flat River, and several miles of trout quality smaller tributary streams. A total of over 275 miles of potential salmon and/or steelhead river will be available for future recreational fishing opportunities in the Grand River Basin. Substantial mileages of valuable spawning and rearing streams will be available to chinook and, where summer stream temperatures permit, coho and steelhead. Naturally reproduced anadromous salmonids are expected to merely supplement hatchery-reared fish, but they may provide appreciable local fisheries on some of the tributary streams.

Dams and the resultant impoundments are not compatible with the aforementioned smallmouth bass management objectives and they inhibit or preclude realization of anadromous fisheries objectives to an even greater degree. The removal of certain dams and installation of fish passage facilities on others will provide substantial sport-fishery benefits. The dams listed in Table V-8 are of primary concern in the anadromous fish programs.

Table V-19

ANALYSIS OF PASSAGE

or DAM REMOVAL ALTERNATIVE COSTS

Dam	Height	Passage Cost*	Structural Removal Cost**
1. Grand Rapids	8 ft.	$25,000	---
2. Lyons	9	30,000	40,000
3. Webber	27	80,000	90,000
4. Portland	12	35,000	50,000
5. Childsdale (Rogue R.)	16	50,000	65,000
6. Rockford (" ")	14	40,000	60,000
7. Ada (Thornapple R.)	22	65,000	90,000
8. Cascade (Thornapple R.)	28	85,000	100,000
9. LaBarge (" ")	17	50,000	50,000
10. Middleville (Thornapple R.)	7	20,000	35,000
11. Irving (" ")	7	20,000	35,000
12. King Mill (Flat R.)	11	35,000	45,000.
13. Lowell #1 (Hydro) (Flat R.)	25	75,000	100,000
14. Lowell #2 (Flat R.)	17	50,000	55,000
15. Smyrna (" ")	8	25,000	40,000
16. Belding (" ")	12	35,000	50,000
17. Greenville (Flat R.)	10	30,000	45,000

* Initial passage cost — Total cost would include annual O & M + portion of structure O & M

** Structure Removal — Sediment removal or control costs not included

The costs of the program of fish passage and/or dam removal will be derived from the final mix of passage vs. dam removal. The current best judgement indicates it would result in fish passage costs of $335,000 and dam removal costs of $515,000.

The full realization of the anadromous fisheries potential in the Grand River Basin will provide 275,000 angler days per year, valued at $1.375,000 annually.

(c) Water Quality Designations. All waters designated under the authority of the Conservation-Sportsmen's Fishing Law (Act 26, Michigan Public Acts of 1967) by the Director of the Michigan Department of Natural Resources will be protected for Intolerant Fish, coldwater species (trout).

The following were provided to the Michigan Water Resources Commission as Michigan Department of Natural Resources recommendations for water quality designations. Those recommendations which are "coldwater species" are accepted by the Michigan Water Resources Commission as Directors Designations of Trout Streams, to be so protected.

a. Grand River should be protected for fish, intermidiate species, except:

1. The mainstem upstream from the Ionia-Clinton County line through the city of Lansing and,

2. The mainstem from Berry Road (Sec. 15, T1S, R1W) through the City of Jackson should be protected for fish, warm-water species.

b. Grand River tributaries should be protected for fish, intermediate species, except:

1. Norris Creek, Steven's Creek and Petty's Bayou tributaries, tributary to Spring Lake should be protected for fish, coldwater species.

2. Lloyd's Derms, Pottawatomi, Melhouse, Stearn's and Robinson's Bayou tributaries should be protected for fish, coldwater species.

3. Black Creek entering at Sec. 28, T8N, R15W should be protected for fish, coldwater species.

4. Crockery Creek -

(a) The mainstem and tributaries from Ravenna (Sec. 2, T9N, R14W) to the Muskegon County line should be protected for fish, coldwater species.

(b) Rio Grande Creek upstream from Blackmer Road (T9N, R14W, Sec.27) and tributaries should be protected for fish, coldwater species.

(c) Sanford (Sec. 1, T8N, R15W) Lawrence (Sec. 31, T9N, R15W) and Tidioute drains (Sec. 11, T9N, R14W) should be protected for fish, warmwater species.

*Intermediate species - Fisheries Division recommended a water use designation for species such as smallmouth bass and walleye, which have habitat requirements more demanding than most "warmwater" species but somewhat less critical than most "coldwater" species. Waters recommended as "Intermediate species" waters were placed in the "Warmwater Intolerant" category by the Michigan Water Resources Commission.

5. Bass River -

(a) Little Bass Creek from Sec. 20, T7N, R14W upstream should be protected for fish, warmwater species and,

(b) Bass River from Sec. 6, T6N, R14W upstream should be protected for fish, warmwater species.

6. Unnamed tributary entering Sec. 8, T7N, R14W should be protected for fish, coldwater species.

7. (a) Deer Creek and tributaries, Rush Creek and tributaries, Buck Creek upstream from 68th Street, S.W., and all tributaries to Buck Creek, Plaster Creek and tributaries, Indian Creek and tributaries and Lamberton Creek and tributaries should be protected for fish, warmwater species.

(b) Buck Creek from junction with Grand River upstream to 68th Street, S.W., should be protected for fish, coldwater species.

8. Mill Creek entering in Sec. 31, T8N, R11W and all tributaries should be protected for fish, coldwater species.

9. Rogue River and all tributaries except Hickory Creek and four unnamed tributaries originating in T10N, R12W, Sec. 12 and Sec. 3, and T9N, R11W, Sec 35 and Sec. 34 should be protected for fish, coldwater species.

10. Bear Creek entering at Sec. 25, T8N, R11W, Egypt and Honey Creeks and all their tributaries should be protected for fish, coldwater species.

11. Thornapple River tributaries:

(a) Campau Lake Drain should be protected for fish, coldwater species:

(b) Coldwater River and tributaries:

(1) Upstream to the Kent County line should be protected for fish, coldwater species.

(2) From the Kent County line upstream to its confluence with the Little Thornapple and the Little Thornapple River to its confluence with Jordan Lake should be protected for fish, intermediate species.

(3) All other tributaries to the Coldwater River should be protected for fish, warmwater species.

(c) Hanna Lake Drain should be protected for fish, warmwater species.

(d) Duncan Creek and its tributaries, upstream from its confluence with Thornapple River (Sec. 15, T4N, R10W) to its junction with unknown tributary at Gazbow Road (Sec. 16, T4N, R10W) should be protected for fish, coldwater species. From this junction upstream to Duncan Lake, it and its tributaries should be protected for fish, intermediate species.

(e) Baker Creek from its confluence with the Thornapple River (Sec. 16, T4N, R10W) to Baker Lake should be protected for fish, coldwater species. All other portions of Baker Creek and its tributaries should be protected for fish, warmwater species.

Exceptions:

Deep Lake Creek from its confluence with Baker Creek (Sec. 9, T4N, R10W) to the section line of sections 14 and 23 should be protected for fish, coldwater species; and from this point to Deep Lake, intermediate species.

(f) Hill Creek from its confluence with the Thornapple River (Sec. 2, T3N, R10W) should be protected for fish, coldwater species.

(g) Glass Creek and its tributaries from its confluence with the Thornapple River (Sec. 1, T3N, R10W) should be protected for fish, coldwater species.

(h) Cedar Creek from its confluence with the Thornapple River (Sec. 26, T3N, R8W) should be protected for fish, coldwater species.

(i) Buckson Creek from its confluence with the Thornapple River (Sec. 34, T3N, R7W) should be protected for fish, coldwater species.

(j) Quaker Brook from its confluence with the Thornapple River (Sec. 35, T3N, R7W) should be protected for fish, coldwater species.

(k) All other tributaries to the Thornapple River in Barry County should be protected for fish, warmwater species.

12. Unnamed tributary entering in Sec. 18 (west side of river) T7N, R10W, should be protected for fish, coldwater species.

13. Unnamed tributaries entering in Sections 3, 9, 10 and 11 of T6N, R9W should be protected for fish, coldwater species.

14. Flat River -

(a) West Branch Creek entering Sec. 4, T10N, R8W upstream from Dickerson Lake Road, Butternut Creek upstream from Lincoln Road, Sec. 34,

T9N, R10W and Curtis Creek entering Sec. 26, T11N, R8W, should be protected for fish, coldwater species.

(b) Dickerson Creek and tributary entering at Section 1, T8N, R8W upstream to Grow Road should be protected for fish, coldwater species - upstream from Grow Road the mainstem and tributaries should be protected for fish, warm-water species.

15. Unnamed tributary entering in Sec. 9, T6N, R8W, Lake Creek and unnamed tributaries entering in Sec. 28, 27, T7N, R7W should be protected for fish, coldwater species.

16. Bellamy Creek and tributaries upstream to Bellamy Road should be protected for fish, coldwater species. Upstream from Bellamy Road should be protected for fish, warmwater species.

17. Sessions Creek, Prairie Creek and tributaries should be protected for fish, coldwater species.

18. Maple River -

(a) Fish Creek and tributaries upstream from Carson City Dam should be protected for fish, coldwater species.

(b) Goose Creek entering in Sec. 33, T7N, R5W should be protected for fish, warmwater species.

(c) Mainstem and tributaries upstream from Ovid should be protected for fish, warmwater species.

19. Sandstone Creek entering in Sec. 15, T1S, R2W should be protected for fish, coldwater species.

(d) Conclusions. Plan A had target years of 1980, 2000, and 2020. Under Plan B, the target year is 1985 instead of 1980.

It was found that 483,300 days of additional fishing opportunity would be required to meet demands in 1985. It was projected that on-going programs would provide 97,300 fishing days leaving 386,000 days of unsatisfied fishing demand. The elimination of the impoundments proposed under Plan A represents a loss of a potential of 802,700 days of fishing opportunity (Table V-22). This loss will be partially offset by the higher quality fishing which will develop if the programs recommended in Plan B are fully implemented. However, fewer days

of fishing will be provided under Plan B.

It is estimated that 665,000 days of fishing opportunity will be required by 1985. Programs outlined in this portion of the addendum could meet a substantial portion of this demand. Plans to intensify on-going programs in conjunction with plans advanced in this section will provide 136,000 fishing days per year as described below.

The net gain in fisherman days which will result from access provided through land-rights acquired under the valley preserve program, and the increased fisheries management programs, will amount to 36,000 fisherman days per year and $54,000 in annual benefits for warmwater and trout fisheries. The anadromous fish benefits which are realized through the valley preserve program and the access provided to stream fishing on the tributaries amounts to 100,000 fisherman days per year and annual benefits of $500,000.

Calculation Example

(1985) - warmwater and trout 80 angler days/mi x 450 mi x $1.50/angler day = $54,000.

(2000) - warmwater and trout 150 angler days/mi x 450 mi x $1.50 angler-day = $101,250.

(67,500 angler days)

Approximately 529,000 days of fishing opportunity would still be left unsatisfied

Opportunity needed by 1986		665,000 days
Valley preserve access and increased management:		
Warmwater and trout fishery		-36,000
		629,000
Anadromous fishery		100,000
Unsatisfied Demand	=	529,000

The program that offers the most promise, and also one that poses many difficult problems requiring hard decisions, is that which recommends the removal of certain dams and the installation of fish passage facilities on others. This, if fully implemented would add fishing opportunities in two

ways. First, it would provide anadromous fish runs up significant reaches of the river and its tributaries. Second, it would restore major reaches of the river to a free-flowing condition in the vicinity of existing gravel and rubble providing a high quality habitat for smallmouth bass. The full implementation of the fish passage and dam removal program in conjunction with the access provided by the valley preserve, recreation nodes, and on-going programs will provide an additional 275,000 fisherman days for anadromous fishes.

Remaining unsatisfied demand	529,000
Fish passage and dam removal	-275,000
Unsatisfied Demand	254,000

The smallmouth bass and other quality sport fisheries resulting from the restoration of major reaches of the Grand River to a free-flowing condition would provide substantial additional fishing opportunity--perhaps enough to make up the deficit.

A mix of Plan A and Plan B, combining portions of each plan, could produce a fish and wildlife program superior to either plan by itself. It is possible to have a complete valley preserve and free-flowing river system and still incorporate some of Plan A. Off-stream impoundments (diked areas) and small impoundments on certain tributaries would add immeasurably to the variety and quantity of both game and non-game species of animals. This combined plan would also provide a significant warmwater and pan fishery as well as a quality coldwater fishery. By careful planning and coordination with landowners and conservation groups the combined plan could be implemented in a way that would enhance the biological productivity and aesthetics of the Grand River basin.

(3) Wildlife

(a) Wildlife Resources. The Basin is rich in wildlife resources. Species of primary importance are the cottontail rabbit, fox-squirrel, whitetailed deer, dabbling ducks, Canada Goose, Greater Sandhill Crane, ruffed grouse, and the ring-necked pheasant.

Although large areas of the basin are intensely farmed, in other areas, farming is declining and former crop and pasture land is idle.

In addition, large regions of the basin are poorly drained and are occupied by large acreages of wooded and open wetlands interspersed with hills and ponds. Consequently, the trend of habitat sucession is toward forest animals such as deer, grouse, and fox squirrels.

Following is the current situation in game populations:

Cottontail Rabbit	Steady or Increasing
White-tailed Deer	Increasing
Waterfowl	Increasing
Ring-necked Pheasant	Decreasing
Fox Squirrel	Increasing
Ruffed Grouse	Spotty

The white-tailed deer has been increasing rapidly with a southern Michigan fall population now estimated at 100,000. The Grand River Basin comprises 30% of the southern Michigan deer range and is estimated to produce 40% of the population, or 40,000. Approximately 50,000 hunters killed 7,000 deer in the Basin in 1970 while expending 250,000 deer-hunter days. The greatest concentrations of deer are found along the wooded water courses.

The cotton-tail rabbit is the number one game animal in terms of the total hunting effort. The fall population of this animal is estimated to be distributed as follows:

Good Range	1 rabbit/2 acres	10% of Basin
Fair Range	1 rabbit/3 acres	50% of Basin
Poor Range	1 rabbit/5 acres	40% of Basin

Although the pheasant is falling off in numbers, there are still good huntable populations in Ottawa and Ingham Counties as shown on the Pheasant Density Map (Figure V-20).

The Grand River Basin is an outstanding waterfowl breeding ground. The Canada Goose and the following ducks: the mallard, blue-winged teal, wood

duck, and black duck are produced in significant numbers. The Basin occupies the center portion (about 1/2 of the total) of some of the most prolific waterfowl habitat in Michigan and is one of the most important waterfowl producing areas in the Great Lakes region.

Approximately 1,000 Canada goslings are raised annually in the Portage Lake area in the northeast quadrant of Jackson County. This could be raised to 3,000 under waterfowl management programs being planned by the State. The 200 acre permanent wetland or "Wildlife Flooding" on the north side of the Maple River and abutting the east side of Route 27 in Gratiot County is a heavy producer of Mallards, Blue-winged Teal, and Coot.

State Biologists have identified and delineated (see Figure V-11) eight high priority waterfowl production regions as listed below.

Waterfowl Wetlands Complexes
First Priority Areas

Portage Lakes Region - The Portage Lakes Region is located in Jackson County. It includes the area in the vicinity of Little Portage Lake and takes in all of the satellite swamps and marshes there including the north portion of the Waterloo Recreation Area located in the NE corner of the county. It also includes Thornapple and Bateese Creeks.

Maple River Region - This region extends along the Maple River from the game area in Gratiot County southwest to the point where the stream confluences with the Grand River. The area also includes the portion of the Grand River between the communities of Muir and Portland.

Barry Region - The Barry State Game Area and all the marshes in the vicinity of M-37 in Barry County.

Grand Haven Region - The Grand Haven area including the Grand Haven State Game Area extending as far east as where Crockery Creek enters into the Grand River.

Second Prioroity Areas

Rose Lake Region - The area in the vicinity of the Rose Lake Wildlife Research Station in Shiawassee, Clinton and Ingham Counties.

Doan Creek Region - Deer Creek, Doan Creek, Deitz Creek and Kalomink Creek. All of these creeks are tributaries to the Red Cedar.

Langston Region - Langston State Game Area and surrounding wetlands.

Flat River Region - Flat River State Game Area and vicinity wetlands.

State biologists have also delineated the location and extent of wooded and open sedge marshes (see Figure V-13). Data developed by the State on Grand River basin wetland potential amounts is as follows*:

Miles of river edge in marsh and sedge	199
Acres of river-related marsh and sedge	20,230
Miles of swamp edge along rivers	849
Acres of swamp related to rivers	11,385
Total miles of river waterfowl habitat	1,048
Total acres of river-associated habitat	31,615

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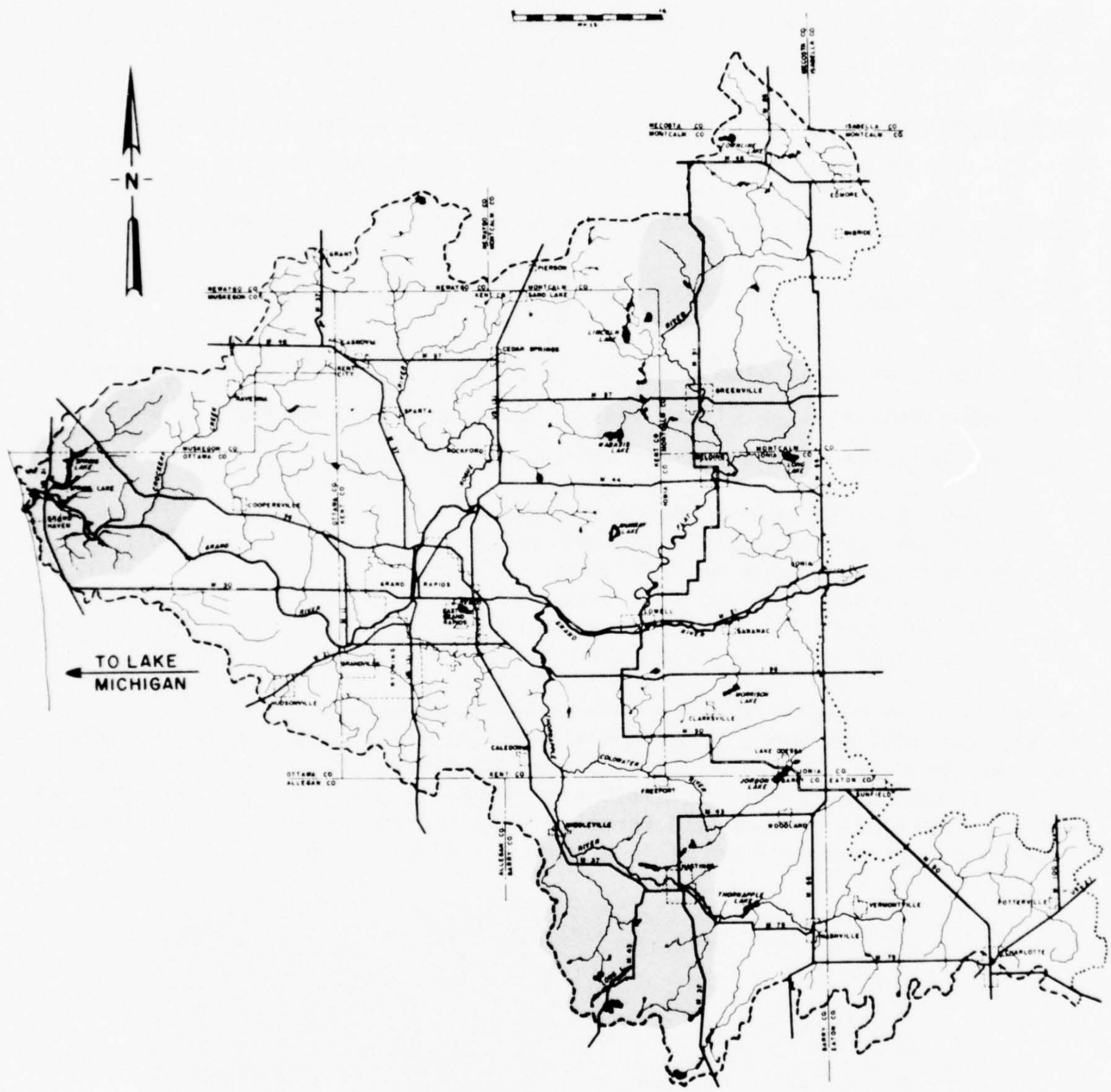
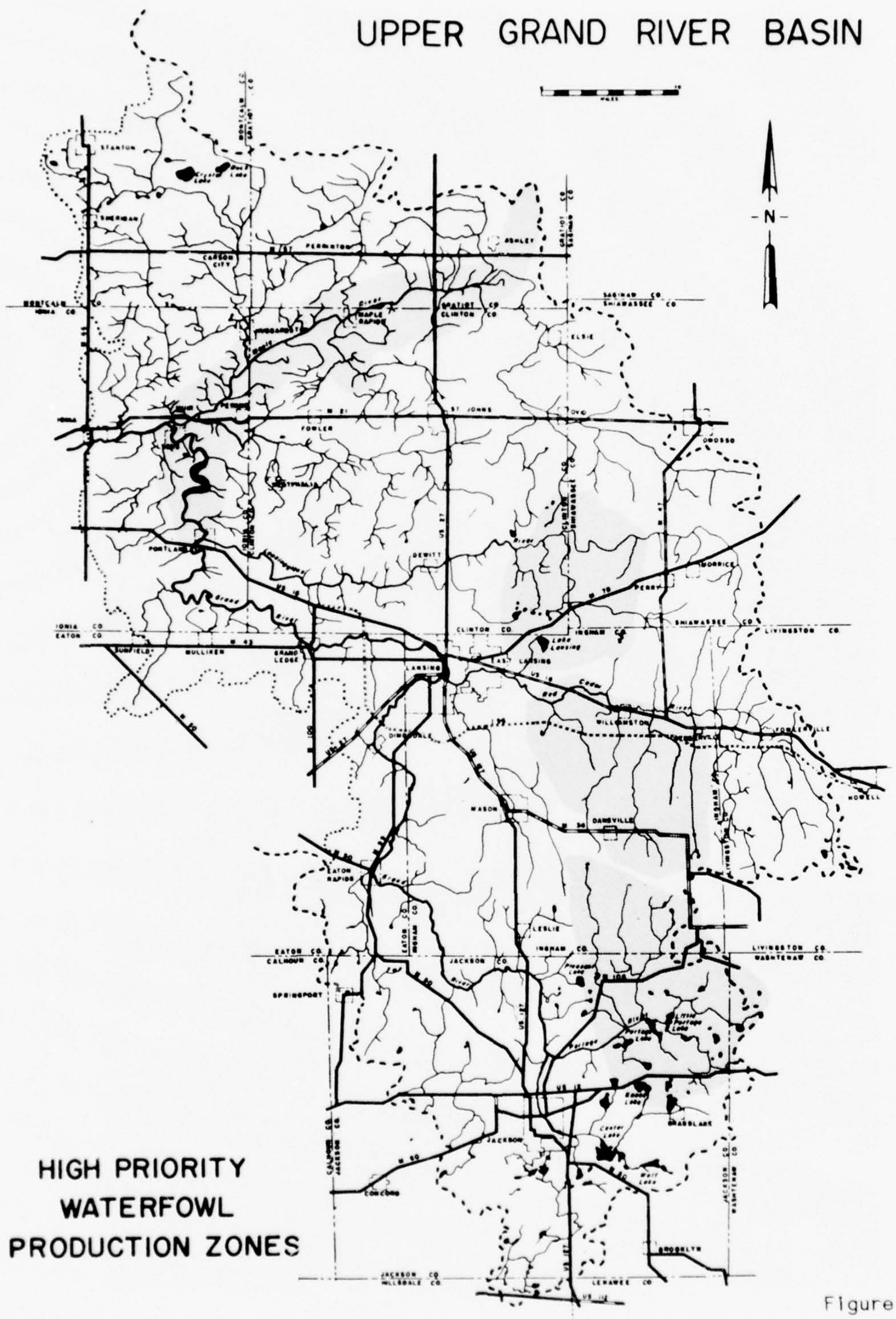
*Swamp includes hardwood trees and shrubs; marsh includes cattails, sedge and marsh grass. River edge miles were doubled to include both sides of each stream considered. An arbitrary figure of a strip one chain wide was used in estimating swamp and marsh acreage on small streams. This averaged out to approximately 8 acres to a mile for minor streams.

Figure V-10. A view of the Maple River wildlife flooding. Another off-river permanent wetland similar to this one is planned for acreage on the opposite side of the road.

LOWER GRAND RIVER BASIN



HIGH PRIORITY WATERFOWL PRODUCTION ZONES


UPPER GRAND RIVER BASIN
N
HIGH PRIORITY
WATERFOWL
PRODUCTION ZONES
STANTON
SHERIDAN
CARSON CITY
ASHLEY
ELSIE
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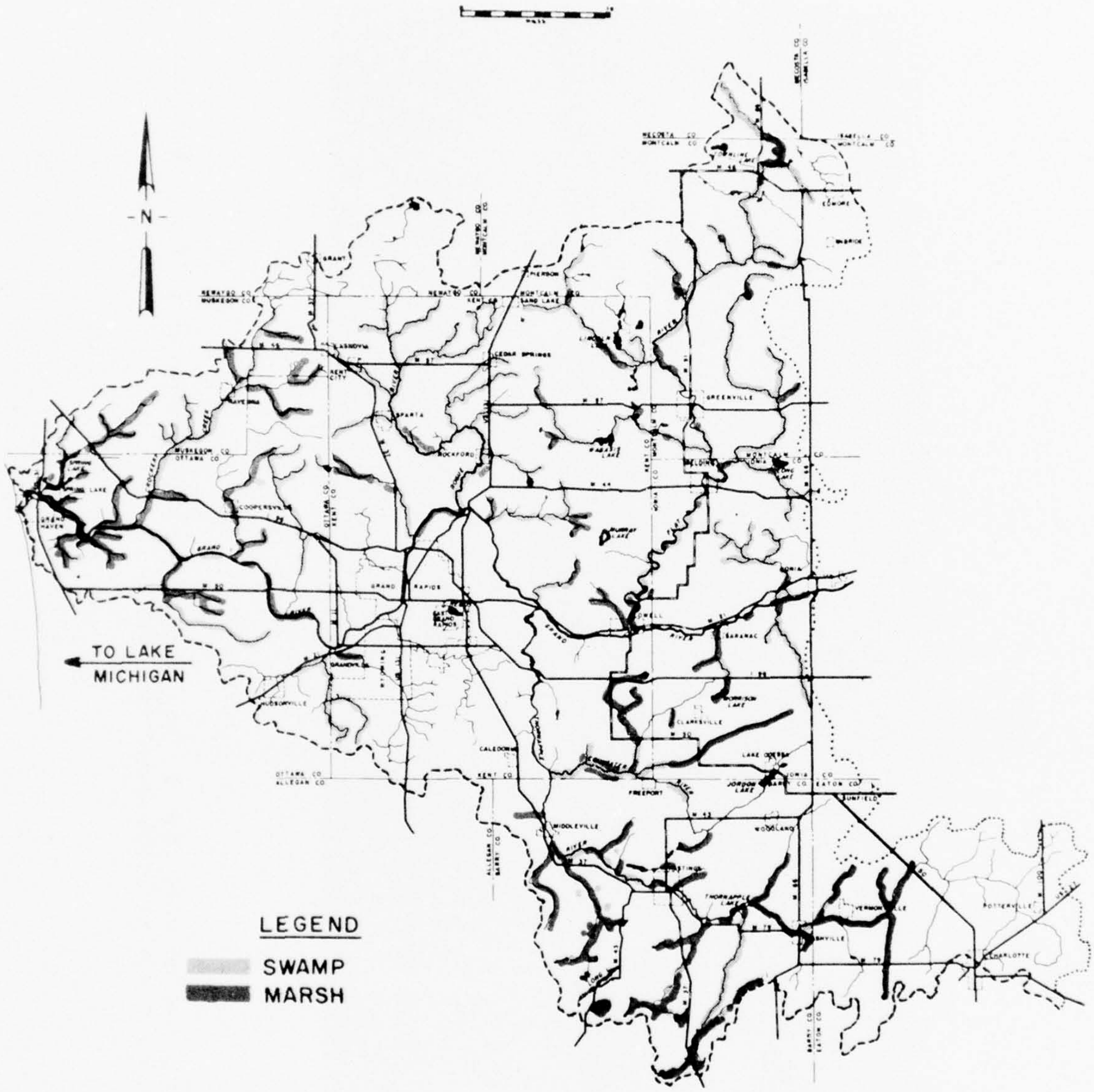
FOWLER
OWOSSO
DEWITT
PORTLAND
MORRICE
PERRY
LANSING
EAST LANSING
GRAND LEDGE
MULLIKEN
WILLIAMSTON
FOWLERVILLE
HOWELL
MASON
DANSVILLE
EATON RAPIDS
LESLIE
SPRINGPORT
JACKSON
BROOKLYN

Figure V-11

Figure V-12. The Grand River basin is an outstanding waterfowl breeding ground. Approximately 1,000 Canada goslings are raised annually in the Portage Lakes area.

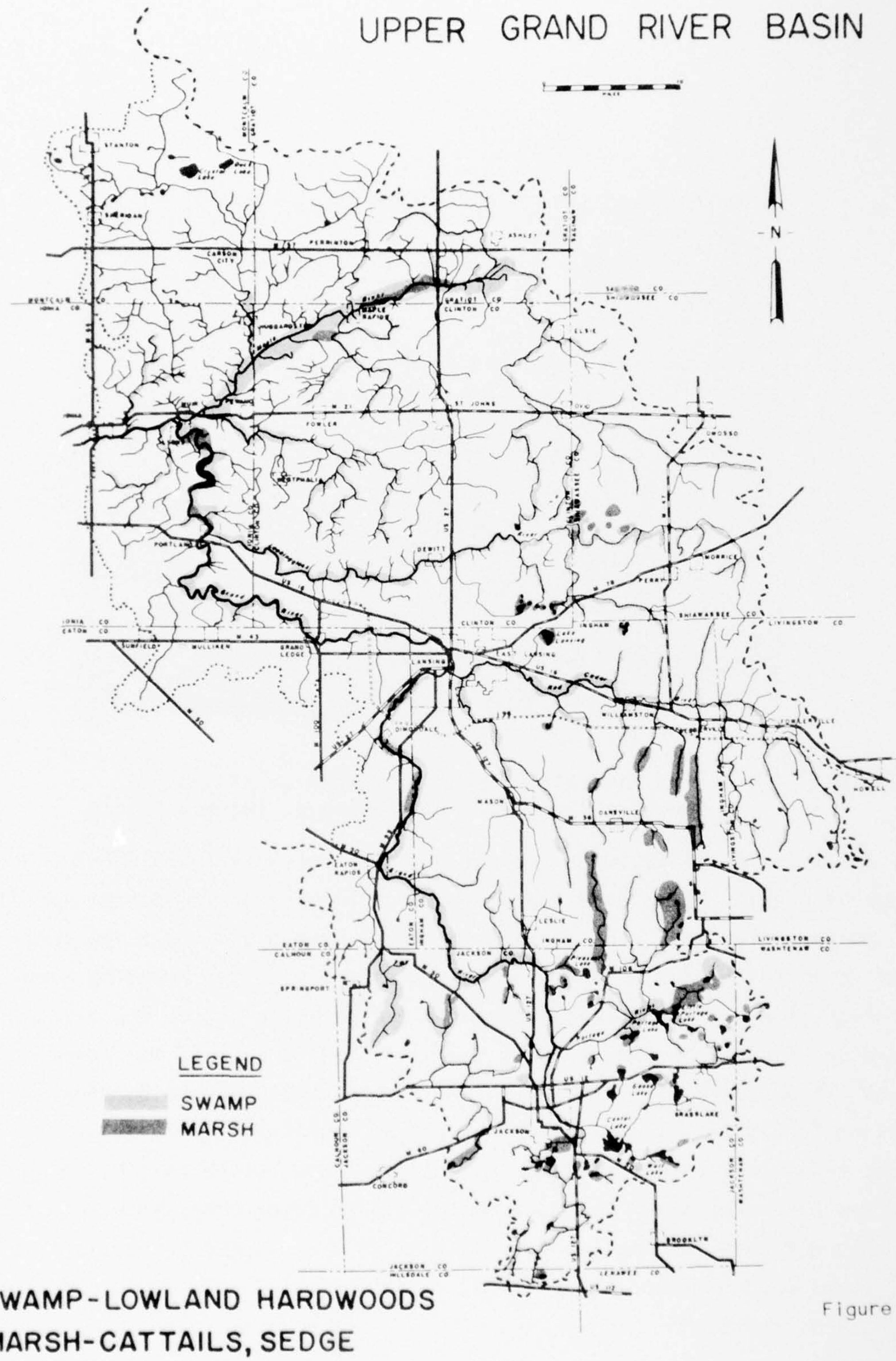
Figure V-13. Panoramic view of Rose Lake at the Rose Lake Wildlife Research Station. Waterfowl and Greater Sandhill Crane production marsh.

LOWER GRAND RIVER BASIN



SWAMP-LOWLAND HARDWOODS

MARSH-CATTAILS, SEDGE



SWAMP-LOWLAND HARDWOODS
MARSH-CATTAILS, SEDGE

Figure V-14

Figure V-15. Active Sandhill Crane nest in center of photo. Schumacher Road, Waterloo Township, Jackson County.

The Basin is important to an unusual and distinctive water bird--the Greater Sandhill Crane. This large and impressive bird breeds in several locations in southern Michigan. The eastern portion of the Grand and a few locations just south of the Basin comprise these southern Michigan breeding grounds. Although data are incomplete a conservative estimate places the number of breeding pairs in the Grand River Basin at 50--the bulk of the breeding Cranes in Southern Michigan. Mud Lake (The Haehnle Audubon Sanctuary) in Jackson County is the most important single location. At lease six pairs breed here and 250 to 300 cranes concentrate here during fall migration. The Mud Lake--Portage River, Jackson County to Boyce Lake, Washtenaw County zone is not only the focal point and axis of prime crane production habitat but is also an outstanding breeding ground for the Canada Goose and several species of ducks.

Seven known breeding ground regions have been identified in the Grand River basin (see Figures V-17, V-18, and V-19). The breeding grounds are:

1.	The Lookingglass River and its tributaries Vermillion and Mud Creeks west of Laingsburg	Clinton County
2.	Rose Lake Wildlife Research Station	Clinton County
3.	Vicinity of Gregory State Game Area	Livingston County
4.	Mud Lake-Portage River-Boyce Lake	Jackson & Washtenaw Counties
5.	Sharonville State Game Area	Jackson County
6.	Area west of Center Lake	Jackson County
7.	Vicinity of Arbor Spring	Jackson County

If these unusual birds are to continue to breed in the Basin, it is imperative that the open, prairie-like character of the lands adjacent to the sedge-cattail wetlands be maintained and that the water levels in the wetlands themselves be held up to sufficient depths (2-3 feet) to prove attractive for not only the cranes but Canada Geese and ducks as well. Of particular concern is the early action 10 miles of channel improvement work being considered in the portion of Portage River which passes Mud Lake. The problem of providing flood control for the muck land farms in the vicinity of the Mud Lake-Portage River-Boyce Lake zone of top quality Canada Goose, duck and crane production grounds while ensuring the continued productivity of this extremely important wildlife unit will require coordinated planning by all levels of government and private conservation organizations.

Figure V-16. The Greater Sandhill Crane is Michigan's largest bird. Seven known Greater Sandhill Crane breeding grounds have been identified in the Grand River basin.

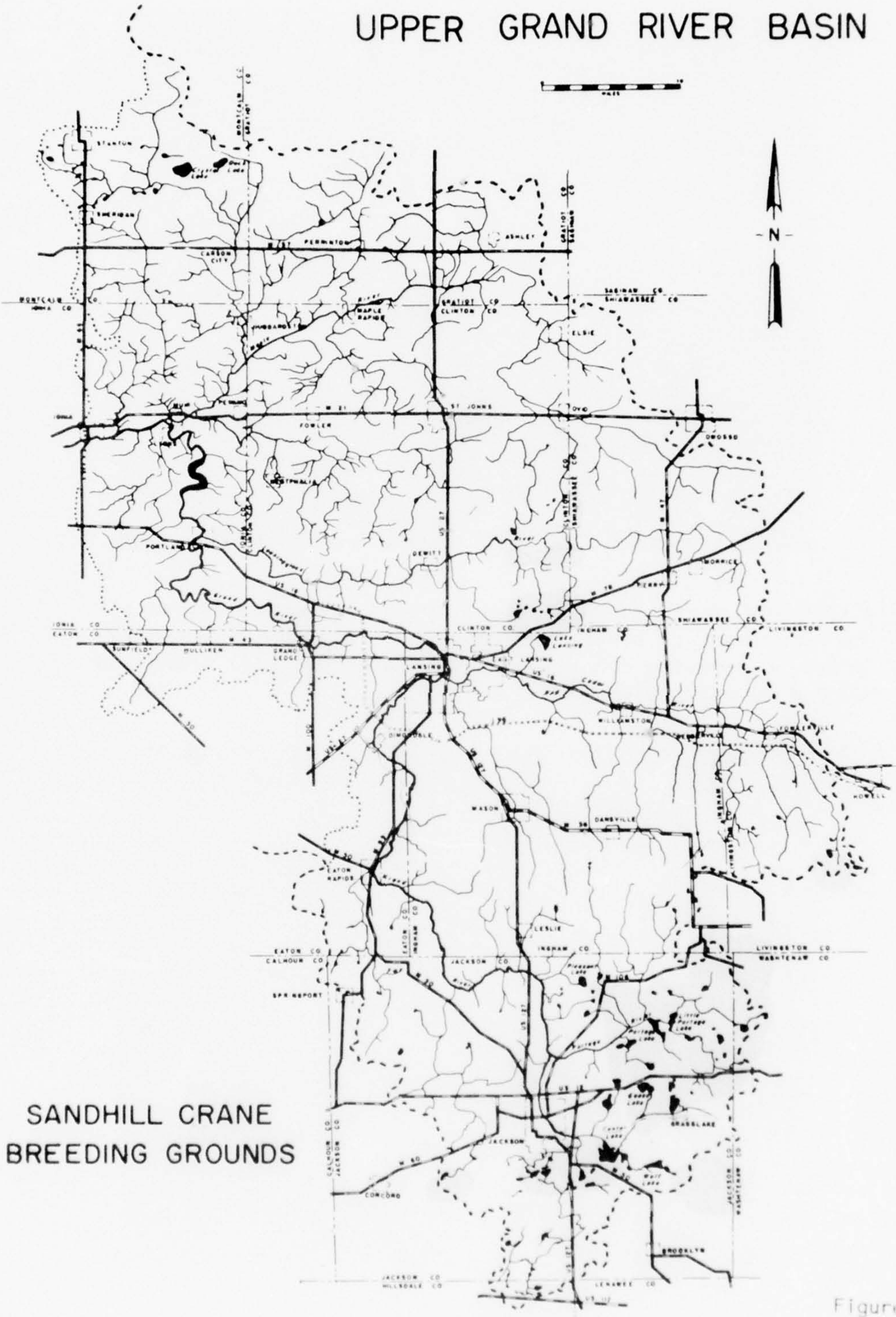

UPPER GRAND RIVER BASIN
N
SANDHILL CRANE
BREEDING GROUNDS
STANTON
SHERIDAN
CARSON CITY
PERRINTON
ASHLEY
ELSIE
ST JOHNS
OVID
OWOSSO
FOWLER
WESTPHALIA
PORTLAND
DEWITT
LANSING
EAST LANSING
GRAND LEDGE
MULLIKEN
WILLIAMSTON
MASON
DANSVILLE
EATON RAPIDS
LESLIE
JACKSON
CONCORD
BROOKLYN
GRASS LAKE
HOWELL
IONIA CO
EATON CO
CLINTON CO
INGHAM CO
SHIAWASSEE CO
LIVINGSTON CO
CALHOUN CO
JACKSON CO
WASHTENAW CO

Figure V-17

Figure V-18. Marsh south of Tophith Road, Waterloo Township, Jackson County. Water level good but invasion of marsh by brush is reducing its value as a Greater Sandhill Crane and Canada Goose nesting ground.

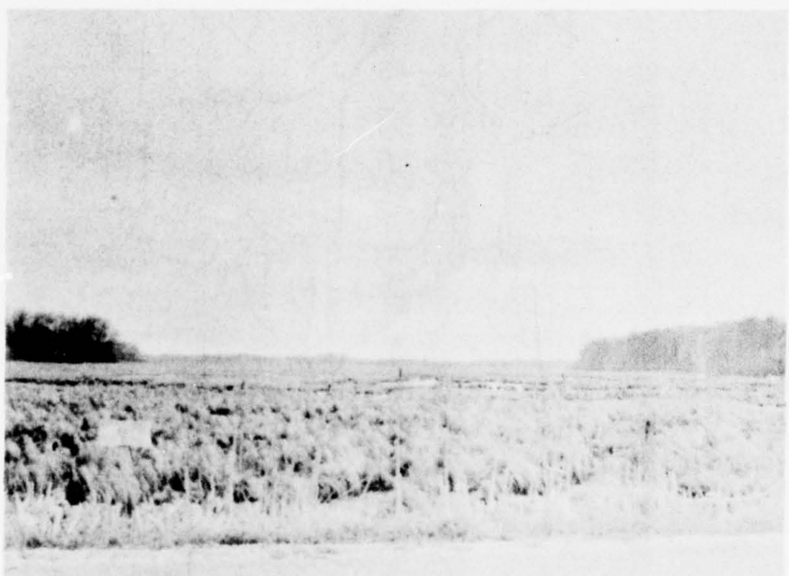


Figure V-19. Crane and goose nesting habitat, Waterloo Township, Jackson, about two miles east of Portage Lake.

PHEASANT DENSITY MAP
FALL 1970

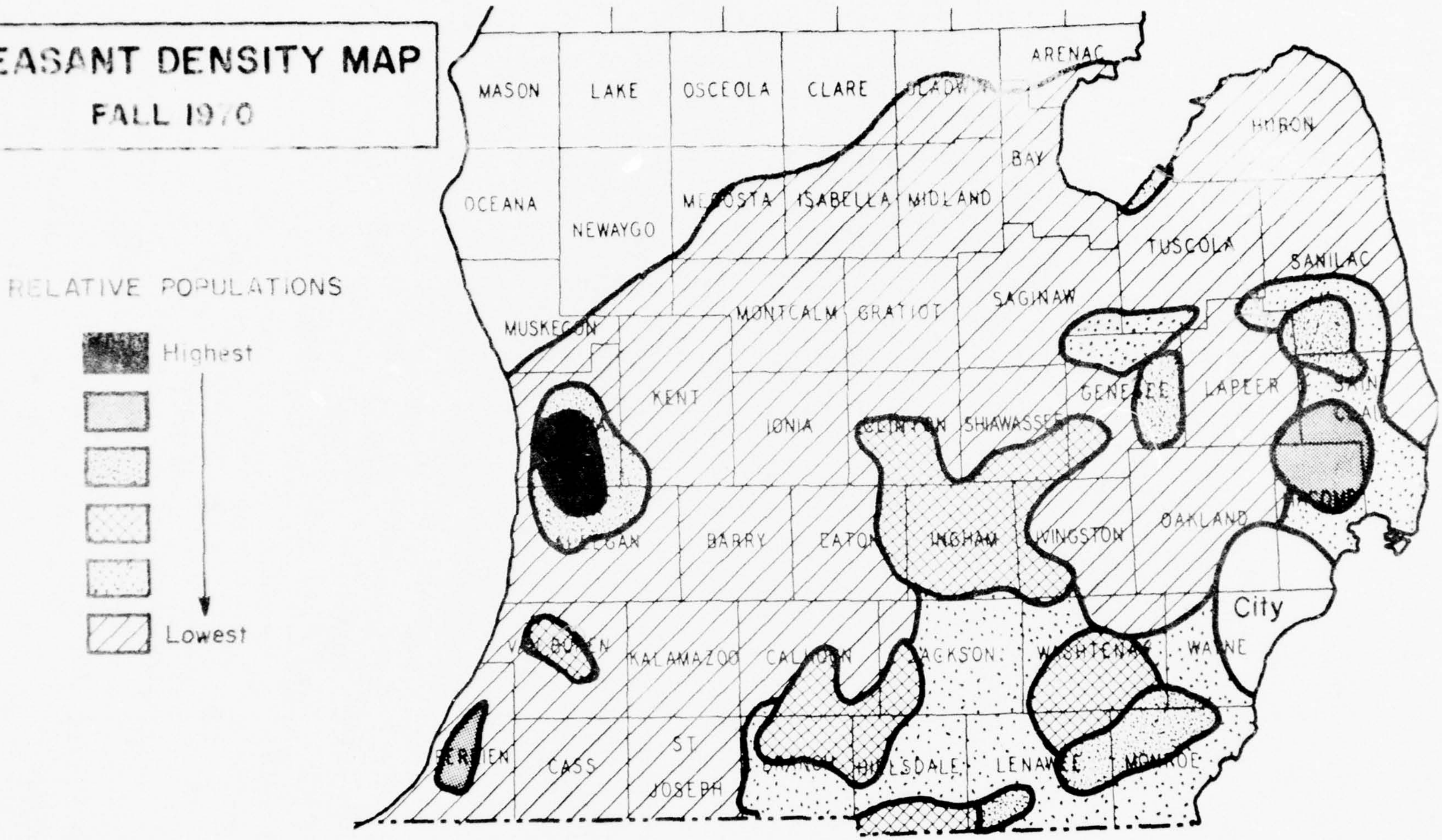


Figure V-20

(b) Wildlife Management. Plan B places emphasis on valley preserves, recreation nodes, and other measures intended to preserve and improve the quality of the environment. This plan, while it will provide for less hunting than plan A, represents an exciting opportunity to preserve in perpetuity large areas for the benefit of mankind. The beneficiaries will be all persons who value open space and appreciate the chance to enjoy an aesthetically pleasing environment.

Since both the valley preserves and the recreation nodes will be managed to provide a mix of recreation with fish and wildlife uses as part of the early action program, 1970-1985, actual benefits to fish and wildlife resources and their users are difficult to accurately assess at this time. However, it is our judgement that low key recreation and hunting and fishing are compatible. It is believed that the opportunity for intensive wildlife management will be considerably less than that for fishery management. The narrow character of the valley preserves will lend themselves more readily to providing fisherman access than for hunter uses. (Since it is impossible to foresee how the valley preserve system will be implemented we have arbitrarily estimated that only half of the huntable acreage would receive use. We have assigned a quality rating to each area based on the judgement of Michigan state biologists.) The recreation nodes, located adjacent to the valley preserve, it carefully planned for low key types of recreation such a picnicking, limited camping, nature study, and so on, should provide some hunting opportunity during the fall and winter season. Tables V-20 and V-21 present our estimates of potential hunter-user days for the valley preserves and the recreation nodes respectively. It is estimated that the recreational nodes and the valley preserves would ultimately provide respectively in addition to the user.days expended on private lands net annual hunter days of 5,840 and 21,070.

The Wildlife Division of the Michigan Department of Natural Resources has 19 state game areas in the basin. Plans for land acquisition and habitat development programs for the period fiscal 1970 through 1975 include the addition of 3,430 acres of land, 800 acres during fiscal year 1970-71 and 2,630 acres during fiscal 1971 through 1975. The Waterloo Recreation Area

managed jointly by the Division of Wildlife and Parks is not included in these figures. This area provides thousands of acres of hunting and fishing. The long range goal acreage for the State game areas in the basin is 151,000 acres. It is estimated that by the end of fiscal year 1975, the State will have completed slightly under 54 percent (81,000 acres) of its goal acreage of 151,000. The 3,430 acres added by 1975 will provide 4,460 gross hunter days, a net gain of 2,090 hunter days over the 1,370 days estimated to have been provided on the 3,430 acres of previously private lands. The remaining 70,000 acres could provide 91,000 hunter days annually, a gain of 63,000 over the 28,000 days provided by private lands.

The State of Michigan wildlife plans call for the development of habitat during the 1970-75 period. Another "wildlife flooding", permanent wetland, is planned to be developed on the west side of Route 27 opposite the existing Maple River wildlife flooding area (see Figure V-10). A 450 acre waterfowl permanent wetland is planned in conjunction with the Soil Conservation Service small watershed project on Hayworth Creek in the Maple River area east of Hubbardston. This project is scheduled for fiscal years 1974 and 1975, at a cost of $120,000. General plans have been made for a large permanent wetland development in the Little Portage River area in Jackson County during the period 1976-1980.

Table V-20

VALLEY PRESERVES:[1/] USE OF WILDLIFE RESOURCES

Area	Miles of Preserve	Total Acres 2/	County	Miles in County	Miles Potentially 3/ Huntable	Species and Remarks	Acres Huntable	Pressure and Quality Rating	Conversion Factor	USER DAYS 4/ Hunter	USER DAYS Non- 5/ Hunter
I-Main Stem of Grand River	215	10,750	Ottawa	41	18	W-in flood plain marshes	1800	1.0		810	2430
					17	Sq, D , Ph, Rac	1700	1.0		760	2280
			Kent	43	10	W-Jump hunting	1000	0.33		150	450
					18	Rab, Rac, some snipe	1800	0.7		570	1710
			Ionia	67	18	W-Jump hunting	1800	0.67		540	1620
					37	D, Rab, Sq, Rac	3700	1.3		2160	6480
			Clinton	7	7	W-Jump hunting	700	0.67		210	630
						D, Rab, Sq, Rac	"	1.3		410	1230
			Eaton	20	14	W-Jump hunting	1400	0.67		420	1260
						D, Rab, Sq, Rac	"	1.3		820	2460
			Ingham	18	10	W-	1000			450	1350
						Ph, Rac	"			450	1350
			Jackson	19	19	W-Jump hunting	1900	0.67		570	1710
						D, Rab, Sq, Rac	"	1.3		1110	3330
			SUB-TOTALS	215	168					9430	28,290
II-Red Cedar River	20	1000	Ingham	20	12	Some W	1200	0.50		270	810
						D, Rab, Sq, Some Ph, Rac	"	1.3		700	2100
			SUB-TOTALS	20	12					970	2910
III-Lookingglass River	30	1500	Ionia	4	3	Some W	300	0.2		030	90
						Good Sq, Rab, D, Rac	"	1.3		180	540
			Clinton	26	26	Some W	2600	0.2		230	690
						Good Sq, Rab, D, Rac	"	1.3		1520	4560
			SUB-TOTALS	30	29					1960	5880

1/ The protection and preservation by both private and public agencies and varying degrees of public use is planned for 22,500 acres along either side of 450 miles of stream.

2/ An average depth of two acres (400 feet) along each side = 50 acres per mile or 100 acres for both sides.

3/ Judgement decision by Michigan State biologist.

4/ Hunter day use per acre per year: 0.4 day - private land
0.9 day - valley preserve
1.3 days - State Game land

$$\text{Hunter Day} = \frac{\text{Acres Huntable}}{2} \times \text{Quality Rating} \times 0.9$$

5/ Non-hunter day use (nature study, etc.) is three times hunter use.

W - Waterfowl
D - Deer
Ph - Pheasant
Rab - Rabbit
Rac - Raccoon
Sq - Squirrel

Table V-20 (Cont'd)

VALLEY PRESERVES: USE OF WILDLIFE RESOURCES

Area	Miles of Preserve	Total Acres	County	Miles in County	Miles Potentially Huntable	Species and Remarks	Acres Huntable	Pressure & Quality Rating	Conversion Factor	USER DAYS Hunter	USER DAYS Non-Hunter
IV - Maple River	30	1500	Ionia	10	9	Some W Good Sq, Rab, D, Rac	900 "	0.2 1.3		80 530	240 1590
			Clinton	12	12	W-Jump, some blind Good Sq, Rab, D Rac	1200 "	1.0 1.3		540 700	1620 2100
			Gratiot	8	8	W-Jump, some blind Good Sq, Rab, D, Rac	800 "	1.0 1.3		360 470	1080 1410
			SUB-TOTAL	30	29					2680	8040
V - Flat River	40	2000	Kent	8	4	W-low Sq, Rab, D, Rac	400 "	0.1 0.4		20 70	60 210
			Ionia	14	11	Some W Sq, Rab, D, Rac	1100 "	0.2 0.4		100 200	300 600
			Montcalm	18	15	Some W Sq, Rab, D, Rac	1500 "	0.2 0.7		140 470	420 1410
			SUB-TOTAL	40	30					1000	3000
VI - Rogue River	40	2000	Kent	40	38	Some W Sq, Rab, D, Rac	3800 "	0.2 0.4		340 680	1020 2040
			SUB-TOTAL	40	38					1020	3060
VII - Thornapple River	50	2500	Kent	19	17	W-low, Some jump and blind D, Sq, Rab, Rac	1700 "	0.2 0.4		150 540	450 1620
			Barry	31	26	W-low, Some jump and blind D, Rab, Sq, Rac	2600 "	0.2 2.0		230 2340	690 7020
			SUB-TOTAL	50	43					3260	9780
VIII - Coldwater River	25	1250	Kent	8	8	W-low, Some jump and blind D, Sq, Rab, Rac	800 "	0.2 0.7		70 250	210 750
			Barry	17	16	W-minor Rab, Sq, some Ph	1600 "	0.1 0.5		70 360	210 1080
			SUB-TOTALS	25	24					750	2260
TOTALS	450	22,500		450	373 (83%)					21, 070	63, 210

Table V-21 RECREATION NODES: USE OF WILDLIFE RESOURCES

Recreation Area	Acres	Present Situation (Private Ownership)		As Recreation Area (Public Ownership)		Gain in Hunter Use Days	Game Species
		Potential Huntable Acres	Hunter Day Use 1/	Huntable Acres	Hunter Day Use 2/		
1. Portland	2700	2700	1080	2050	2660	1580	Deer, waterfowl, Fox Squirrel and rabbits
2. Muir	3000	3000	1200	2900	3770	2570	All four
3. Sandstone	4600	3600	1440	2700	3510	2070	Squirrel and rabbit
4. Lowell	1500	950	1230	470	610	-620	Squirrel and rabbit
5. Ionia (Now 100% huntable because of no development)	2000	1800	2340	1380	1790	-550	Squirrel and rabbit
6. Rockford (If used for intensive recreation, hunting opportunities would be reduced)	1500	1500	600	750	980	380	Squirrel, rabbit and waterfowl
7. Diamondale	700	500	200	500	650	450	Squirrel and rabbit
8. Plainfield (If used for intensive recreation, hunting opportunities would be reduced)	2000	2000	800	600	780	-020	Squirrel and Early waterfowl
9. Grandville (If used for intensive recreation, hunting opportunities would be reduced)	2100	2000	800	600	780	-020	Squirrel and Early waterfowl
TOTALS	20,100	18,050	9690	11,950	15,530	5840	

1/ A factor of 0.4 hunter days per year per acre was used for private lands.

2/ A factor of 1.3 hunter days per year per acre was used for public lands.

Table V-22

Net Hunting and Fishing-User Days Lost by Elimination of Reservoirs

(Target Year 1980)

Plan Sub-area	Hunter Days	Fishing Days
Grand Rapids	29,250	266,000
West Central	44,200	171,100
Lansing	26,580	220,200
Northeast Fringe	2,600	8,700
Jackson	42,900	136,700
TOTAL	145,530	802,700

(c) Conclusions. Although hunting is an important activity in the Grand River basin the non-hunter type of activity such as nature study, bird watching, nature photography, and so on is considered to be of at least equal importance. Methods of measuring and projecting non-consumptive user demands have not been perfected. However, studies by state game agencies have shown that this type of use is often twice that of the hunter in terms of user days.

Plan B which emphasizes the preservation and low key recreational use of open space will enhance the opportunity for non-consumptive uses. Modest gains will be made in hunter use.

Plan A found that hunting opportunity would exceed demand by 48,200 days by target year 1980. After that, hunting demand would start to exceed opportunity. The elimination of the impoundments proposed under Plan A represents a loss of potential of 145,000 days of hunting.

It is estimated that 111,000 additional days of hunting opportunity will be required by 1985. The valley preserves and recreation nodes are expected to provide respectively 21,100 and 5,800 additional days of hunting per year. This coupled with the carry-over in Plan A would leave only one-fourth of the demand unsatisfied:

Opportunity needed by 1985		111,000 days
Carry-over		-58,200
		52,800
Recreation areas		-5,800
		47,000
Valley Preserves		-21,100
Unsatisfied Demand	=	25,900

The deficiency projected in hunting opportunity is an optimistic estimate -- it could be much higher. Accelerating the state's game lands acquisition program would make up this deficiency as well as providing for the increasing demand of non-consumptive (non-hunter) users. Use of the same open space by both the hunter and non-hunter is compatible. Experience has shown that the bulk of the state game lands receive heavy use from non-hunters.

It is anticipated that the State will have achieved about 54 percent of its goal acreage of 151,000 acres by 1975. The remaining 46 percent, 70,000 acres, could provide 91,000 hunter days - a net gain of 63,000 days over the 28,000 provided by private lands. All types of persons who enjoy the out-of-doors will be benefited by these 70,000 acres. Appendix K indicates that

Figure V-21. These wetlands in Grand Haven just west of Route 31 are still important aquatic bird areas but are threatened by "progress". Diked wetland top photo had blue-winged teal and coots at time of photo. Junk cars threaten to obliterate cattail marsh in bottom photo.

Figure V-22. Mud Lake at the Haehnle Santuary of the Michigan Audubon Society. Preservation of this valuable Greater Sandhill Crane, waterfowl and aquatic animal habitat by this private group is an example of an outstanding wildlife conservation effort. More and continued action of this kind will be necessary to make Plan B a success.

changes in land use and availability of huntable habitat will result in accelerating loss of habitat:

Present to 1980	151,000 acres
1980 to 2000	224,000 acres
2000 to 2020	282,000 acres
Total Loss	657,000 acres

If 10 percent of this loss, 70,000 acres, could be diverted and the land put into state game areas, the combined benefit to hunter and non-consumptive (nature study, etc.) users would be 273,000 user days -- 91,000 hunter days and 182,000 non-hunter days. With the escalating price of land, an early program of acquisition would provide more land per dollar spent and would hedge against inflation. Bold programs of financing will be necessary if the Grand River basin is to retain and improve in the amount and quality of open space.

The single, most important consideration from a wildlife standpoint is the extensive areas of wetlands and the aquatic bird breeding grounds they provide. The Grand River basin occupies the center portion (about one-half of the total) of some of the most prolific waterfowl habitat in Michigan and is one of the most important waterfowl producing areas in the Great Lakes region. The Canada Goose, the Greater Sandhill Crane, and several species of ducks are among the valuable animals breeding here in significant numbers. State biologists have identified over 31,000 acres of productive wetlands associated with the basin's streams - 20,200 acres of sedge-cattail swamps and 11,400 acres of hardwood swamps (see Figure V-10). Some of this habitat will be acquired or placed under protective custody as part of the valley preserve program. An additional but unknown acreage of wetlands exists as potholes and intermittent wet areas scattered throughout the basin. Approximately 13,000 acres of wetlands will come under public ownership as part of state game areas when the ultimate goal acreages are reached. This will include both scattered wetlands and stream associated wetlands. These wetlands considered worthless swamps by many uninformed persons, are being filled, dug up, drained, and altered at an alarming rate. It is especially important that preservation of the wetlands located in the four top priority waterfowl wetlands regions - Portage Lakes, Maple River, Barry and Grand Haven be made the first order of business in any and all plans for the

Grand River basin. It will take public and private groups working together to accomplish the perpetuation of this productive habitat. Potential conflicts involving land use and wetland habitat, exist in the four areas mentioned above. Watershed planning is active in the Upper Maple River region and development in this area will probably be completed in 10 - 15 years. Considerable precautions are being taken to protect and enhance wetland habitat in these projects through coordinated planning efforts. The Bureau of Sports Fisheries and Wildlife supports all efforts to include habitat preservation and development in project planning, but is concerned with any channel work which could result in the draining of wetland areas. The Portage Lakes unit, a priority I waterfowl region and Greater Sandhill Crane nesting ground (see Figure V-11) should be preserved by both outright purchase and agreements with landowners.

The preservation and control of the Grand River basin wetlands and adjacent habitat will be in the best interest and will be more appreciated as the years go by.

(4) Recommendations. The major thrust of Plan B is toward the preservation and wise use of the Grand River basin with the objective of providing a mix of the natural scene with modest recreational facilities. A carefully planned and coordinated program could provide maximum use of the region's resources while maintaining the environment in a natural and aesthetically pleasing condition. Both the hunter and non-hunter will profit. The recommendations set forth below are aimed at providing the maximum use. A summary of estimated costs and benefits pertaining to recommended fish and wildlife programs are presented in Section VI.

Plan B recommends:

(a) That the on-going acquisition program of state game lands be maintained to 1975 as projected by the Wildlife Division of the State.

(b) That an accelerated program of acquisition of the 70,000 acres of land needed to meet the State's goal acreage for the 19 state game areas in the basin, be initiated not later than 1975 and be completed by 1985. At least 50 percent of the estimated $14 million dollars could come from Federal sources.

(c) That the State's intensified on-going warmwater and trout fishery program for controlling rough fish populations in trout waters and the lake and stream reclamation program be continued.

(d) That the valley preserve program for providing access be implemented immediately so that the full benefits of the intensified on-going fisheries program and the developing anadromous fishery program can be realized.

(e) That the combination of fish passage and dam removal program described in (2) (d) Fisheries Management be implemented not later than 1973 starting with the Grand Rapids dam and working upstream.

(f) That top priority be given to the water quality program so that the fishery benefits associated with recommendations (c), (d), and (e) can be realized.

(g) That private conservation organizations as well as all levels of government be encouraged to acquire or control and preserve unique areas and valuable fish and wildlife habitat.

(h) That the Water Bank Program (PL 91-599) of the Agricultural Stabilization Conservation Service be implemented not later 1973 with first priority given to those wetlands where a conflict exists between agricultural practices and the management and use of these areas for fish and wildlife purposes.

(i) That tax relief, cost sharing programs, easements, and other means be devised and legislation passed if necessary to provide monetary incentives to landowners to manage their land for fish and wildlife purposes.

(j) That a Federal grant program be instituted making funds available to qualified biologists (to either individuals or to agencies) to study and survey the wetlands and factors related to the Greater Sandhill Crane breeding grounds known to exist in the Basin with special emphasis on the Portage Lakes region.

(k) That consideration be given to some type of a user fee for public lands where one interest is supporting use by other interests; e.g., State game areas are financed with fishing and hunting fees but are used by many non-sportsmen.

(l) That a special wetlands fund be established from both State and Federal sources to provide for the acquisition, or lease of productive wetlands identified in the study and cited in recommendation "(p)" below.

(m) That consideration be given to the establishment of a major State-Federal private agency with responsibilities to manage waterfowl, Greater Sandhill Crane, and aquatic animals in the Portage Lakes region.

(n) That legislation be enacted or existing laws be implemented to prohibit the dredging, filling and altering of wetlands by both private and public agencies without a permit from the State.

(o) That 10,000 acres of the 31,000 acres of stream associated wetlands delineated on the fish and wildlife map be acquired by the State. This is in addition to those wetlands acquired incidental to the valley preserve program or as part of the goal acreage for the state game areas.

(p) That the State complete, not later than 1973, an inventory of the extent and quality of the Basin's wetlands so that this information can be used in wildlife management planning.

f. Flood Damage Reduction.

(1) Introduction. Flood damage reduction measures consist of structural and nonstructural programs performed by Federal agencies, States, and local organizations. These measures include reservoirs, channel improvements, levees and dikes, channel stabilization, sediment control, flood forecasting, watershed management and land treatment practices, flood proofing, and flood plain regulations.

Several communities in the basin experience annual flood damages. Structural alternative solutions were developed to meet these needs and are described in Appendix H, Flood Control, and in Section III herein. As a result of public reaction to Plan A (pages V-1 thru V-4), Plan B provides for a minimum of structural flood protection works. Therefore, local units of government should actively promote and enforce the use of available non-structural programs and techniques to reduce flood damages in the Grand River basin. Enforcement of these measures would assure that flood plain lands are committed to uses compatible with the flood hazard.

A number of non-structural flood damage reduction measures* which should be carried out to reduce flood damages in the basin are described in the following paragraphs.

(2) Flood Forecasting. Flood forecasting and flood fighting provide opportunities for the implementation of emergency measures to minimize damages by evacuation of persons and movable objects from areas expected to be flooded.

The timely and proper utilization of effective flood forecasting and flood fighting programs, together with an established flood plain management plan, could provide substantial reductions in the loss of property caused by floods. This method of flood fighting is especially effective in areas where the benefit-cost ratio does not justify piblic investment in flood control structures.

Flash floods resulting from high-intensity short-duration rainfall account for considerable loss to movable property. The warning time for communities subject to this type of flood is short. It is feasible to establish reporting networks around the communities and to train local representatives in the use of forecast procedures. Technical developments in radar and its application to the

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*Plan B structural and non-structural flood prevention and drainage programs pertaining to agriculture are discussed on pages V-266 through V-285.

precipitation, temperature, and other data. These data are available on punch cards and are published in Climatological Data and Hourly Precipitation Data bulletins for Michigan.

A State weather forecasting center is maintained at Detroit. In addition to daily State-wide public weather forecasts, other special forecast services, including quantitative precipitation forecasts, severe weather warning, and other climatological weather services for the Grand River Basin, are rendered by the local Weather Service offices.

(3) Flood Plain Regulation.

Flood plain regulation or land use programs do not attempt to reduce or eliminate flooding but are designed to mold the flood-plain development in such a manner as to lessen the damaging effects of floods. Flood-plain regulations imply the adoption and use of legal tools, by communities, with which to control the extent and type of future development which will be permitted in the valleys. For these controls to be effective, it is necessary that the public understand the general flood problem, the degree of risk, and the methods that can be used to control use of the land. There are various means of effecting such flood-plain management.

A designated floodway is the area of channel and those portions of the flood plains adjoining the channel which are reasonably required to carry floodwaters. Encroachment lines are the lateral boundaries of the floodway, one on each side of the river. No construction or land filling should be permitted between these lines if these works will interfere with the floodwaters.

Zoning is the legal tool that is used to implement and enforce the detailed plans resulting from the planning program. It is used by towns, cities, counties, and agencies of the States to control and direct the use and development of land and property within their jurisdiction. Zoning insures the safekeeping of property for the public health and welfare and the best use of available land. Division of communities into various zones should be the result of a comprehensive planning program for the entire area. Designated floodways may be zoned for the purpose of passing floodwaters and for other limited uses that do not conflict with that primary purpose. The ordinance may also establish regulations for the flood-plain areas outside the floodway. These include designating elevations below which certain types of development cannot be constructed.

A subdivision can be defined in a broad sense as a tract of land divided into lots for the purpose of sale or building development. Subdivision regulations are used by local governments to specify the manner in which land may be divided. They may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of land, freedom from flooding, size of floodways, and other points pertinent to the welfare

of the community. Not only can public health and welfare benefit, but various municipal costs such as maintenance of streets and utilities can be reduced during flood periods. Subdivision regulations provide an efficient means of controlling construction in presently undeveloped floodplain areas. The following typical provisions which could be added to regulations would be helpful to flood damage prevention:

Show extent of the flood plain on subdivision maps,

Show floodway limits or encroachment lines,

Prohibit fill in channel and floodway that would restrict flow,

Require that subdivision roads be above the elevation of a selected flood level, and

Require that each lot contain a building site with an elevation above a selected flood level.

A building code, a set of regulations adopted by a local governing body, provide standards for the construction of buildings and other structures to serve in the interest of the health, safety, and general welfare of the public. A well-written and properly enforced building code can effectively reduce damages to buildings in the flood plain. A few of the requirements which should be specified in a building code to reduce flood damages are:

Prevent flotation of buildings from their foundations by requiring proper anchorage,

Establish basement elevations and minimum first flood elevations consistent with potential floods,

Require structural strength to withstand water pressure or high velocity of flowing water,

Restrict the use of materials which deteriorate rapidly when exposed to water, and

Prohibit equipment that might be hazardous to life when submerged, such as chemical storage, boilers, or electrical equipment.

Wise day-to-day policy and action decisions to prevent construction of streets and utility systems in undersirable areas will deter development in flood plains. Street improvements, schools, and other public facilities located elsewhere wield a "soft-sell", negative influence on flood-plain exploitation and a positive leadership toward the higher ground.

(4) Flood proofing

Flood proofing consists of those adjustments to structures and building contents which are designed or adapted primarily to reduce flood damages. Such adjustments can be scheduled to be undertaken in existing buildings during periods of remodeling or expansion. Also, they can be incorporated into new buildings during initial construction at locations where studies have shown that such buildings would constitute a proper use of a flood plain.

Flood proofing, like other methods of preventing flood damages, has limitations. It can generate a false sense of security and discourage the development of needed flood control or other actions. Indiscriminately used, it can tend to increase the uneconomical use of flood plains. Applied to structurally inadequate buildings, it can result in more damage than would occur if the building were not flood proofed.

The flood proofing technique also presents certain practical difficulties. A complex pattern of land and building ownership would present problems in cooperation before a community-wide program of flood proofing could be carried out. In addition, retail businesses as well as houses frequently change ownership and this tendency would discourage investments for producing primarily long term flood protection benefits. Another complication is the requirement of accurate and timely flood forecasts for successful flood proofing operations in some areas.

Flood proofing has important values when treated as part of a broader program for comprehensive flood plain management. Continued occupance of developed flood plain sites, and even new development of such sites, may become necessary in some low lying areas--especially in certain urban areas where a shortage of land may offer no alternative.

In addition to its principal values of permitting occupance in flood plains and enabling a building to function during flood periods, flood proofing has some other benefits:

1. It offers an additional tool in a comprehensive flood damage reduction program.

2. It can increase the protection afforded by partial protection flood control projects.

3. It may approve the availability of flood insurance.

4. Properly understood, it can increase interest in flood damage reduction programs by heightening the awareness of flood risk.

The characteristics of flooding vary from flood plain to flood plain and the type of development on flood plains is highly diverse. This variation makes it difficult to select the flood damage reduction instruments best suited to a given flood plain situation unless a detailed analysis is undertaken. The appropriateness of flood proofing in any given region depends upon the stage of flooding, the velocity of flow, the duration of the flood period, the uses being made of the flood plain, and the relationship of flood proofing to other flood damage reduction measures.

A flood proofing program would normally warrant serious consideration as a means of flood damage reduction in the following circumstances:

> Where studies have concluded that it is not economically feasible to provide flood control structures, flood proofing could provide a substitute means of reducing flood losses.
>
> Where authorized flood control projects have not been constructed because of lack of local cooperation, flood proofing could provide property owners with an opportunity to reduce their flood risk.
>
> Where utilities, manufacturing plants, and navigation terminals require riverfront locations to function effectively, flood proofing could provide the owners of these facilities an opportunity to achieve a degree of flood damage reduction. The highest practicable level of protection should be afforded to assure continuation of utilities.
>
> Where flood proofing and flood insurance are closely allied, a property owner could elect to flood proof to reduce his flood risk in order to obtain more favorable flood insurance rates.
>
> Where flood control projects have provided only partial flood protection, flood proofing could enable property owners to achieve a higher degree of protection than would otherwise be provided.

In actual cases where buildings have been flood proofed in accordance with plans developed with professional engineering and architectural assistance, flood proofing has performed satisfactorily and has mitigated flood losses.

(5) Permanent Evacuation of the Flood Plain.

Permanent evacuation of developed areas subject to inundation involves the acquisition of lands by purchase (through the exercise of the powers of eminent domain, if necessary), the removal of improvements, and the relocation of the population from such areas. Lands acquired in this manner could be used for agriculture, parks, or other purposes that would not interfere with floodflows or result in material damage from floods.

Great emphasis is being placed on the growing need for vastly increased areas for recreational and other open-space uses. Areas adjacent to streams and other bodies of water have a natural attraction and are readily adaptable to recreation and open areas. Parks, playgrounds, and picnic areas can utilize lands which would not be suitable for facilities requiring permanent structures. A number of localities throughout the country are using flood plains for such purposes and are reaping secondary benefits from the flood damage prevention. Federal grants are made to assist communities in acquiring such open-spaces when linked with a program of comprehensive planning.

Urban renewal can be used in flood-blighted areas that are a drain on the economic life and welfare of the community and do not lend themselves to other methods of regulation and control. The Federal Urban Renewal Program provides substantial assistance to municipalities burdened with such conditions.

A redevelopment program should include flood-control works where appropriate and necessary as well as setting aside the lower flood-plain areas for parks, open-spaces, and other uses not subject to substantial flood damages. Public parking areas may be designated, provided adequate regulations or precautions are established. To minimize flood damages, the upper areas can be utilized for new structures.

(6) Other Measures.

A method which may be used to discourage development is the erection of flood warning signs in the flood-plain area or the prominent posting of previous high-water levels. These signs carry no enforcement but simply serve to inform prospective buyers that a flood hazard exists.

Tax adjustments for land dedicated to agriculture, recreation, conservation, or other open-space uses may be effective in preserving existing floodways along streams. Unless such concessions are made, farmland adjacent to communities will become more valuable each year as residential or commercial developments move into parts of it, which will cause tax evaluation of all adjacent farmland to rise to the point where the land no longer can be used profitably for farming or other open uses.

Very little building is carried on without financing. Therefore, lending institutions, both Federal and private, are in a position to exercise some control over flood-plain development by denying mortgage guarantees or funds to subdivision or individual builders.

Community expansion brings about the desire for more stream crossings. From a construction standpoint, perhaps the most economical method of providing crossings consists of roadways on earth embankments, with a small bridge or culvert to pass streamflows. However, this is often the least desirable from a flood damage point of view. If the structure is kept at a low elevation, it is frequently flooded and fails to serve its intended purpose. If the roadway is kept high, above the flood plain, it will act as a dam and increase flood stages upstream unless the waterway opening is adequate. Therefore, all future stream crossings should be designed to provide:

Adequate waterway openings,

Adequate bridge clearance above floodflows, and

Adequate roadway height above floodflows.

(7) Flood Plain Information.

(a) Introduction. The flood plain information program authorized by Congress provides for the Corps of Engineers, Department of the Army; Soil Conservation Service, Department of Agriculture; and Geological Survey, Department of the Interior; and other Federal agencies to prepare and disseminate information with respect to flood plain management to Federal, State, and local planning agencies.

Section 206 of the 1960 Flood Control Act (Public Law 86-645, as amended) authorizes the Corps of Engineers to participate in the flood plain information program by preparing and disseminating Flood Plain Information (FPI) reports and by providing other technical services. The Soil Conservation Service prepares Flood Hazard Analyses (FHA) reports in cooperation with the Michigan Water Resources Commission under the authority of Section 6 of Public Law 83-566, in accordance with Recommendation 9(c) of House Document No. 465, 89th Congress, 2nd Session. The Geological Survey and other Federal agencies; in accordance with House Document No. 465; also take part in carrying out the flood plain information program.

(b) Flood Plain Information and Flood Hazard Analyses Reports.

As stated above, the Corps of Engineers prepares and disseminates FPI reports. FPI reports contain historical and potential flood data which can be easily understood and utilized by State and local planning agencies as well as Federal agencies in promoting our ultimate objective - the wise and best use of the flood plains. The Corps also provides other technical data, e.g., flood proofing and flood plain regulation information.

The Soil Conservation Service prepares and disseminates FHA reports. FHA reports contain delineated flood hazard areas, high water profiles, flood plain soil surveys and soil interpretation data for use by Federal, State and local governmental agencies and other organizations participating in the management of flood plains.

Studies conducted in connection with the preparation of FPI and FHA reports include field investigations and the collection of flood plain data originating with local coordinating agencies such as watershed,

conservation, or basin planning organizations. In the State of Michigan, priorities regarding the location and extent of flood plain information and flood hazard analyses studies are set by the Michigan Water Resources Commission.

Figure V-23 shows the reaches of streams where FPI and FHA studies have been completed and those that are planned to be undertaken in the basin. Figure V-24 indicates how land areas within the floodplain may be used to reduce flood damages. Tables V-23 and V-24, respectfully, list the FPI and FHA studies that have been completed and those that are planned to be carried out in the basin.

FPI and FHA reports attempt to achieve the following objectives:

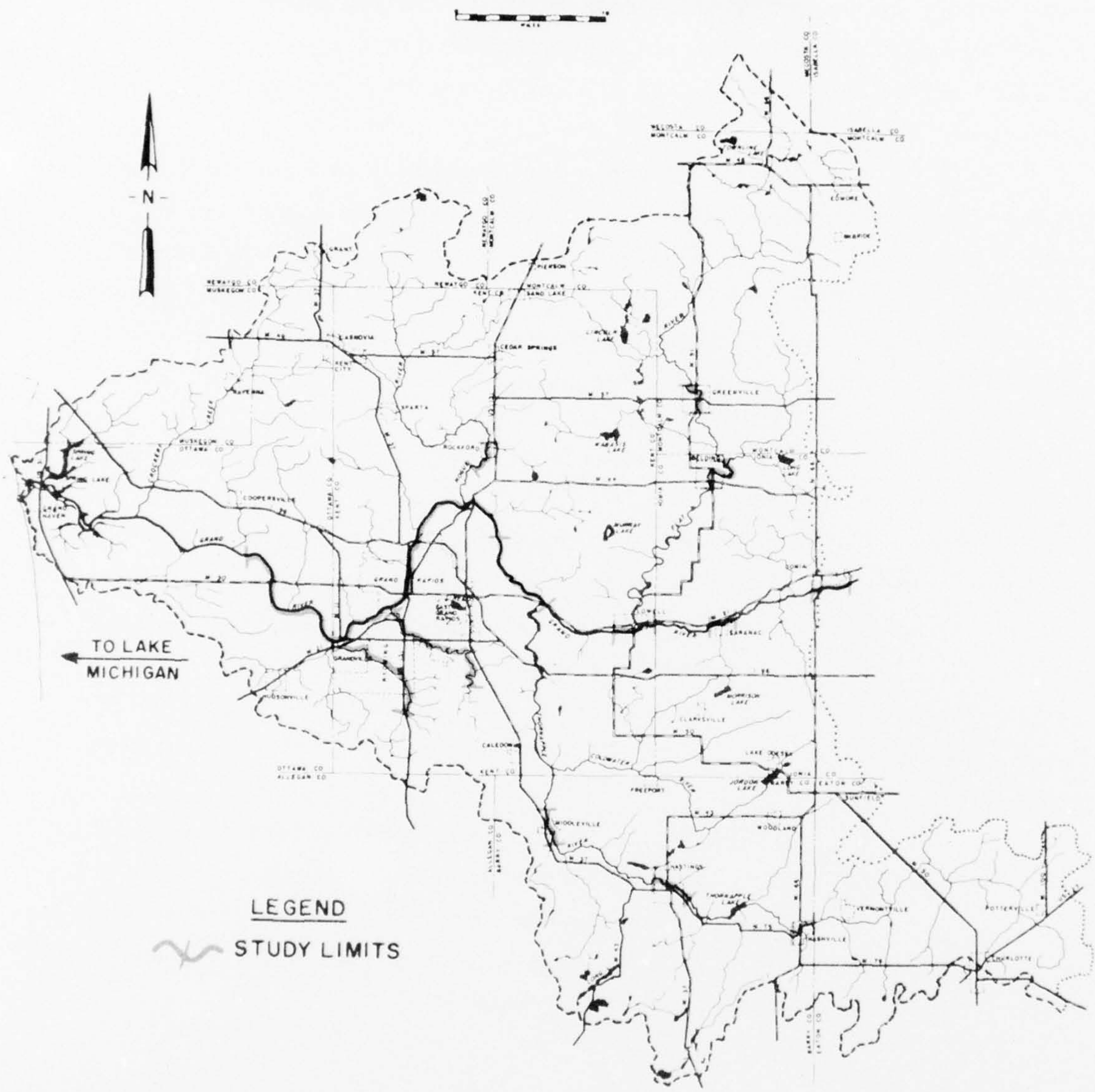
a. Compile and present in clear and useful form all pertinent information relative to past and potential flood hazards including identification of areas subject to inundation by floods of various magnitudes.

b. Encourage prudent use of our river valleys by providing a basis for state or local regulation of flood plain uses, promoting the preparation of land use plans which preserve an adequate channel to accommodate flood flows.

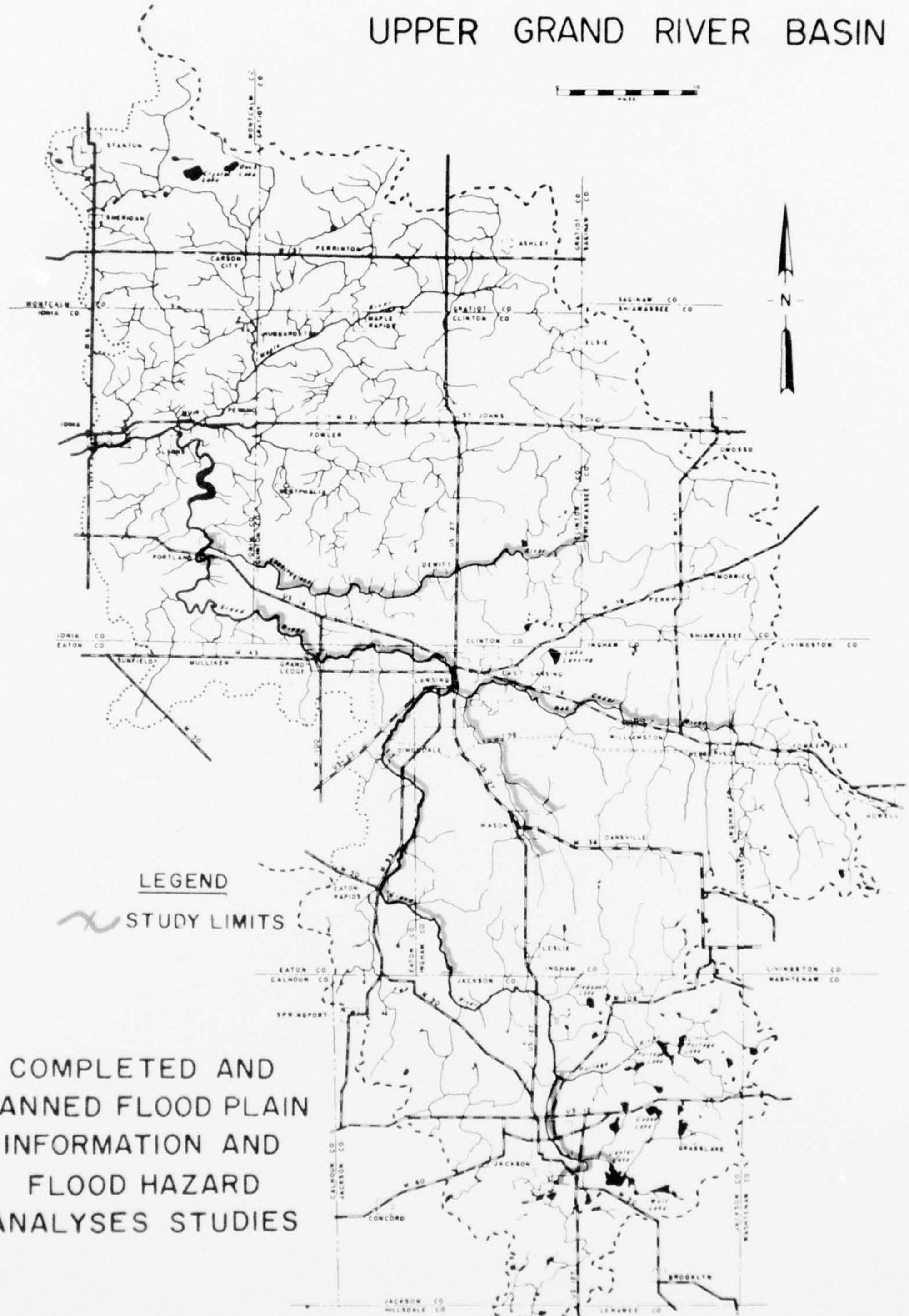
c. Publicize in an understandable form information to guide interests in either local or general areas of concern..

d. Minimize the need for flood control projects to protect future development which could otherwise have been built thereby perpetuating the concepts of environmental preservation.

LOWER GRAND RIVER BASIN



COMPLETED AND PLANNED FLOOD PLAIN INFORMATION AND FLOOD HAZARD ANALYSES STUDIES



COMPLETED AND
PLANNED FLOOD PLAIN
INFORMATION AND
FLOOD HAZARD
ANALYSES STUDIES

Figure V-23

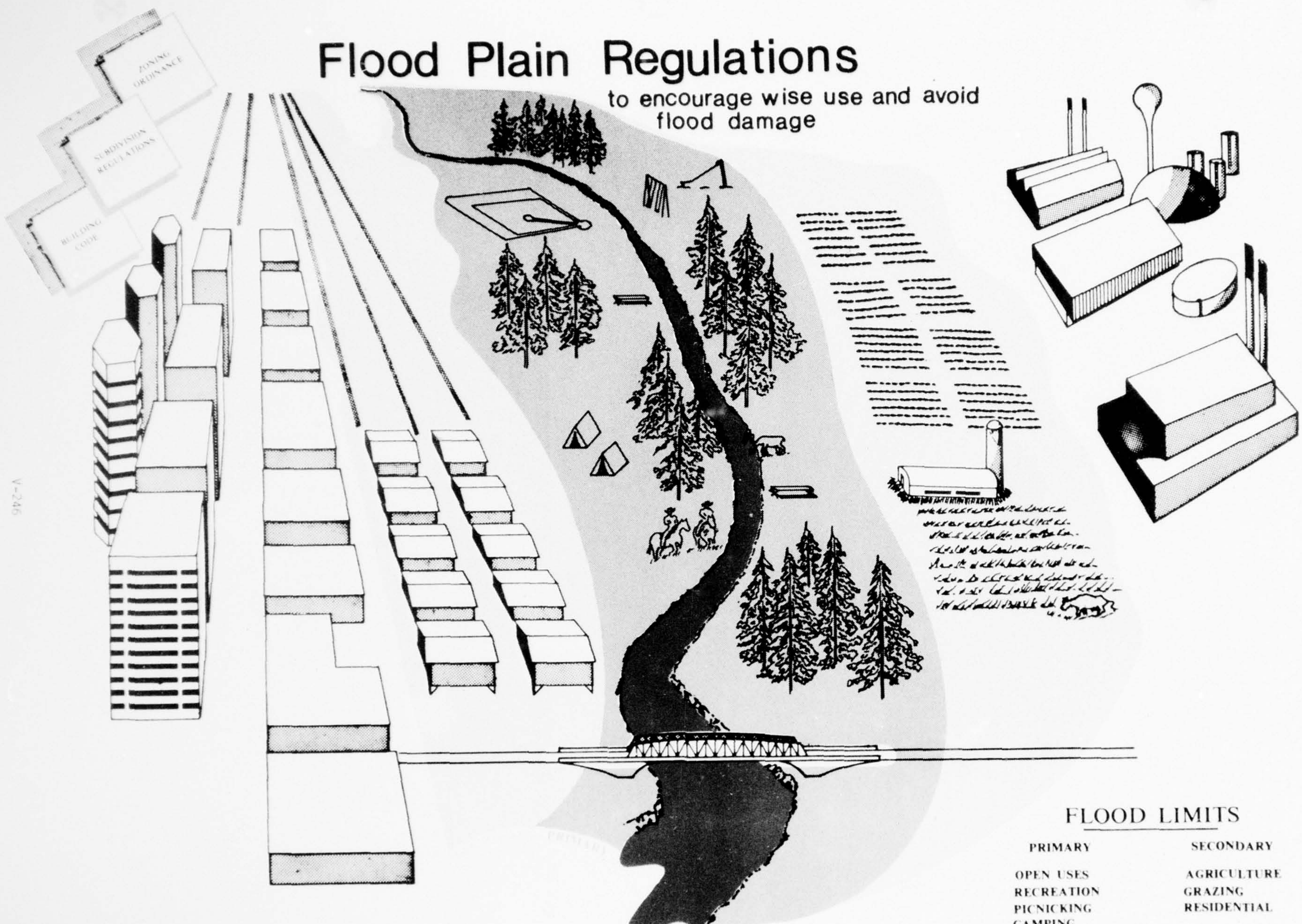

Flood Plain Regulations
to encourage wise use and avoid flood damage
ZONING ORDINANCE
SUBDIVISION REGULATIONS
BUILDING CODE
PRIMARY
PRIMARY
FLOOD LIMITS
PRIMARY
SECONDARY
OPEN USES
RECREATION
PICNICKING
CAMPING
HORSEBACK RIDING
AGRICULTURE
GRAZING
RESIDENTIAL

Figure V-24

Table V-23 FLOOD PLAIN INFORMATION AND FLOOD HAZARD ANALYSES REPORTS

Report	Agency	Date Completed	Stream	Study Reach
Ingham and Eaton Counties (FPI)	COE	1969	Grand River	From the Dimondale Dam in Dimondale to the Ingham-Jackson County line, Eaton and Ingham Counties, Michigan.
Ingham County (FPI)	COE	March 1968	Red Cedar River	From the Michigan State University Dam in East Lansing to the Straight Dam in Williamston
Lansing and vicinity (FPI)	COE	April 1970	Grand River, Red Cedar River, and Sycamore Creek	On the Grand River, from the Grand Ledge Dam to the Dimondale Dam; on the Red Cedar, from the confluence with the Grand River to the Michigan State University Dam on Sycamore Creek, from its mouth to the Holt Road Bridge
Clinton County (FPI)	COE	December 1969	Looking-glass River	From the Ionia-Clinton County line covering DeWitt, the Wacousta area, the Charter townships of Watertown and Bath, the Townships of DeWitt, Olive, Eagle, and Victor to the Clinton-Shiawassee County line.
Grand Rapids (FPI)	COE	September 1971	Grand River	From the Kent-Ottawa County line through the cities of Grandville, Walker, Wyoming, and Grand Rapids; through Comstock Park, Plainfield Heights, and through the townships of Plainfield and Cannon to the Cannon-Ada township line.
Plaster Creek (FPI)	SCS	June 1971	Plaster Creek	From the confluence of Plaster Creek and the Grand River in Kent County through the cities of Wyoming, Grand Rapids, and Kentwood to 60th Street. Also tributaries Little Plaster Creek to Patterson Avenue and Whiskey Creek to 28th Street.
Buck Creek (FHA)	SCS	June 1972	Buck Creek	From confluence of Buck Creek and Grand River to Kent-Allen County line near 108th Street.

Table V-24

FLOOD PLAIN INFORMATION AND FLOOD HAZARD ANALYSES STUDIES

Studies Under Application

Stream	Study Reach
Grand River	FPI study from the east city limits of Ionia to the west city limits.
Grand River and Lookingglass River	FPI study: Grand River from south city limits of Portland to north city limits. Lookingglass River from east city limits of Portland to Grand River.
Grand River	FPI study from the east Kent County line through the city of Lowell to west city limits.
Thornapple River	FPI study from Center Road through the city of Hastings to the west city limits.
Flat River	FPI study from the north city limits of Greenville to the south city limits.
Grand River	FHA study from the east line of section 1 to the west line of section 2 all in Boston Township through the village of Saranac.
Flat River	FPI study from the north line of section 12, T8N, R8W, through the city of Belding to the south city limits.
Grand River	FHA study in Blackman Township: on the Grand River from the Maple Grove Road up through the city of Jackson to Probert Road; on the north branch of the Grand River, from its confluence with the Grand River, to Center Lake; and on the Portage River, from its confluence with the Grand River, to the Blackman-Leonia Township line.
Rogue River	FPI study from the north city limits of Rockford to the Childsdale Avenue Bridge.
Thornapple River	FPI study from the south line of section 26 through the village of Middleville to the north line of section 22.
Thornapple River	FPI study from the east village limits of Nashville to the west village limits.

Table V-24 (Cont'd)

Stream	Study Reach
Sycamore Creek and Mud Creek	FPI study: Sycamore Creek from Holt Road to Tomlinson Road; Mud Creek from the confluence to Columbia Road.
Red Cedar River	FPI study from Williamston to the Ingham-Livingston County line.
Grand River	FPI study from Clinton-Ionia County Line to Grand Ledge.
Grand River	FPI study from the north city limit of Grand Rapids to the west city limits of Walker and G andville.
Grand River	FPI study extending from the west Tallmadge Township line through Tallmadge and Georgetown Townships to the Ottawa-Kent County line.
Grand River and Thornapple River	FPI study on the Grand River extending from the Cannon-Ada Township line upstream through the city of Ada to the Ada-Cascade Township line and on the Thornapple River from its confluence with the Grand River upstream to the Ada- Cascade Township line.

(8) National Flood Insurance Program

The National Flood Insurance Program was established by the Housing and Urban Development Act of 1968 to make specified amounts of flood insurance, previously unavailable from private insurers, available under Federal auspices. In return for the provision of subsidized insurance to existing properties, the Act requires that State and local governments adopt and enforce land use and control measures that will guide development in flood-prone areas in order to avoid or reduce future flood damage. A 1969 Amendment to the Act expanded the definition of flood to include mudslides, and mudslide area restrictions are also required, wherever applicable.

Authority under the Act has been delegated to the Federal Insurance Administrator in the 21.5 Housing and Urban Development (451 7th Street, S.W. Washington, D. C. 20410). The program is a cooperative effort between the Federal Government and the private insurance industry, which is represented by the National Flood Insurance Association.

To qualify for the program, a community must submit to the Administrator a written request to participate in the flood insurance program for the entire area under its jurisdiction. The documentation required by the regulations governing the flood insurance program must accompany the written request.

Although there is no application form, the Administrator will, on request, furnish local officials with a copy of a checklist entitled Prerequisites for the Sale of Flood Insurance describing the documentation prescribed by the program regulations which is necessary to qualify for flood insurance. Local officials must submit a copy of the land use and control measures which have been adopted in compliance with the standards set forth in program regulations.

Assistance in qualifying for flood insurance is available directly from the Federal Insurance Administration. The Governor of every State and the Commonwealth of Pureto Rico has appointed a State coordinating agency to assist communities in qualifying for the program and in the development of acceptable land use and control measures.

When a community becomes eligible, notice is published in the Federal Register, and officials of the community are advised by letter of the date that the sale of insurance will commence. The local news media is advised of the action. Local insurance agents and brokers are informed individually of the availability of coverage by NFIA.

After a community begins participating in the flood insurance program, flood insurance policies may be purchased from any property and casualty insurance agent or broker licensed to do business within the State.

Effective 1 March 1972, all structures used for residential, business, regigious, or agricultural purposes, structures occupied by nonprofit organizations, and structures owned by State or local government agencies thereof are eligible for flood insurance coverage.

Flood loss claims are processed in the same way as loss claims for other types of property insurance. Claims may be filed either with the local insurance agent or broker who sold the policy or with the local insurance company that issued the policy.

The policy covers losses resulting from a flood, which is defined in the flood insurance policy as "a general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudslides which are caused or precipitated by accumulations of water on or under the ground." The policy does not cover water or mudslide damage which results from causes at the location of the insured. It does not cover water or mudslide damage unless a flood, as defined above, occurs in the area where the insured property is located and the water or mudslide damage is clearly the result of that condition.

It does not cover erosion losses or losses resulting from floods or mudslides already in progress at the time of application for coverage. Sewer backup losses are not covered, except where a general condition of flooding exists and the sewer backup is clearly a result of that condition.

Insurance at subsidized premimum rates may be purchased for any existing building or for any building whose construction was started before the date the community was identified as a hazardous area, and for any new construction outside the areas of special flood hazards. Insurance at the subsidized rates may be purchased in amounts up to $17,500 for single family residential structures (including townhouses or rowhouses) and up to $30,000 for all other structures. Contents coverage is available at subsidized rates in amounts up to $5,000 per unit and may be purchased by either the owner or the tenant.

Subsidized premimum rates, which became effective on 10 July 1972, are shown below:

Type of Structure	Value of Structure	Rate Per Year Per $100 Structural Coverage	Rate Per Year Per $100 Contents Coverage
(1) Single family residential	$17,500 and under	$0.25	$0.35
	17,501 - 35,000	.30	.40
	35,001 and over	.35	.45
(2) All other residential	30,000 and under	.25	.35
	30,001 - 60,000	.30	.40
	60,001 and over	.35	.45
(3) All non-residential (including hotels and motels with normal occupancy or less than six months in duration)	30,000 and under	.40	.75
	30,001 - 60,000	.50	.75
	60,001 and over	.60	.75

Upon completion of a rate study for the particular community, additional coverage equal to the amounts available at the subsidized rates, will be available at actuarial rates.

Although no minimum amount of insurance is required, the amount of coverage should be adequate for anticipated losses. The minimum premium charged on each policy is $25, and there is a $4 minimum charge for any change in coverage during the term of a policy.

The amount of the deductible, applicable separately to both the structure and the contents, is either $200 or 2 percent of the amount of the loss, whichever is greater.

To avoid duplication of benefits, the act provides that Federal disaster assistance will not be available to reimburse property losses to the extent that the losses are covered under flood insurance policies. The act also provides that no Federal disaster assistance will be available to reimburse losses that occur after 31 December 1973 to the extent that the owner could have obtained flood insurance and failed to do so. This latter requirement would apply only if flood insurance had been available in the community for at least one year. It would not be applicable to low income persons.

The Federal Insurance Administration has been authorized to provide subsidized flood insurance until 31 December 1973 without first determining the individual community's actuarial premium rates, which is a prerequisite for coverage under the regular program. The emergency program is intended primarily as an interim program to provide earlier coverage for potential flood victims pending the completion of actuarial studies. The Federal Insurance Administration has no authority under the emergency program either to offer the higher limits of coverage or to offer subsidized premium rates to new construction. New construction cannot be covered under the emergency program but must wait until actuarial premium rates have been established. The emergency program does not affect the requirement that a community must have adequate land use and control measures in effect in order to participate in the flood insurance program.

For inland and coastal regions, the special flood hazard area generally means any area which has a one percent annual chance of flooding. The special mudslide hazard area is any area with a high potential for mudslides.

The Federal Insurance Administrator is responsible for identifying the special flood or mudslide hazard areas and for supplying the community with the technical data necessary to the development of a sound mangement program for flood and mudslide prone areas. The Administrator may initiate technical studies through other Federal agencies, State, or local agencies, or through private engineering firms, or he may utilize existing data. In any event, no expense for the study will accrue to the community.

Flood plain management means the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, and land use and control measures.

Land use regulations can be helpful in allocating unprotected lands to their most appropriate uses and in preventing private and public landowners from burdening other landowners or the public with the cost of losses resulting from the unwise use of floodprone lands.

Although each State has the primary authority to control land use, in most cases local governments have been granted this authority. Minimum standards for local ordinances have been published by the Federal Insurance Administrator. Local governments must show evidence that decisions concerning the location, design, and construction of new structures will take known flood hazards into account. This type of control is generally accomplished through a building permit system and sub-division regulations.

Within six months after the Administration has furnished new technical data more precisely defining the hazards, additional land use and control requirements, based on the data furnished, will have to be met.

Whether land use controls apply to existing structures is determined by the laws of the community in which the property is located. From a Federal standpoint, however, such controls must apply to all new construction or substantial improvement of properties located in the special flood hazard area begun after the date the flood hazard area is identified by the Administrator.

The land use measures must be applied equally, at least to all known special flood or mudslide hazard areas within its jurisdiction.

Land use measures that do not fully meet the standards prescribed in the regulations may be adopted if exceptional conditions exist that make adherence to such standards premature or uneconomic. The nature, extent of, and reasons for any variances from regulatory standards should be explained in writing and supporting economic, topographic, hydrologic, and other technical data submitted with the copy of the land use measures sent to the Administrator.

(9) Cost of Non-Structural Programs. The cost of implementing non-structural flood protection programs which includes permanent evacuation and flood plain regulation measures has generally been the responsibility of local interests. However, in recent years, the Corps of Engineers has recommended local flood protection plans that included non-structural measures (e.g., the Prairie du Chien, Wisconsin, proposed flood control project described below. These local protection plans included cost-sharing arrangements that provided for Federal participation.

The overall cost of satisfying permanent evacuation, flood plain regulation, and flood proofing needs in the Grand River basin has not been established.

The cost of preparing and disseminating flood plain information reports and providing other technical services to States and other Federal and local agencies is also a Federal responsibility. To date, the Corps of Engineers has expended approximately \$190,000 to perform flood plain information studies in the Grand River basin on specific reaches of the Grand, Red Cedar, and Lookingglass Rivers. These are now completed studies.

Ongoing flood plain information studies on other reaches of the Grand River are expected to cost approximately \$130,000 of which \$56,000 has been expended. Other flood plain information studies scheduled to be conducted in the basin are estimated to cost approximately \$250,000. The Soil Conservation Service has expended approximately \$80,000 on Flood Hazard Analyses in the basin.

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GRAND RIVER BASIN MICHIGAN. COMPREHENSIVE WATER RESOURCES STUDY--ETC(U)

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(10) Proposed Non-Structural Flood Control Project at Prairie du Chien, Wisconsin. The District Engineer of the St. Paul, Minnesota District, Corps of Engineers, in 1970, submitted to higher authority an "Interim Survey Report for Flood Control, Mississippi River at Prairie du Chien, Wisconsin." Non-structural flood control measures are included as the plan of improvement at Prairie du Chien. The recommended cost-sharing arrangement for the proposed project calls for Federal participation.

The non-structural flood control measures recommended include: (1) permanent evacuation, (2) flood plain regulation, and (3) flood proofing. The total cost of the proposed project is estimated at $1,640,000, based on July 1970 price levels.

In the absence of an established cost-sharing policy for Federally sponsored local flood protection projects in which evacuation and flood plain regulation measures are recommended as the plan of improvement, a number of alternative cost-sharing arrangements were considered. However, the alternative recommended for the proposed project is an 80 percent Federal and 20 percent non-Federal cost-sharing arrangement.*

The proposed non-structural flood control project report for Prairie du Chien, to date, has not received Congressional authorization. The Board of Engineers for Rivers and Harbors, Corps of Engineers with minor revisions, endorsed the plan. It is now undergoing review in the Office of Management and Budget prior to being forwarded to the Congress.

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* It has been established that the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) is applicable to the proposed non-structural flood control project at Prairie du Chien. Under Public Law 91-646, funds could be provided for implementation of the recommended Prairie du Chien plan provided it receives Congressional authorization.

(11) Local Protection.

(a) Lansing.

A flood control protection scheme for Lansing has been authorized by Congress for construction (House Document No. 132, 84th Congress, 2nd Session, dated 27 June 1956).

The plan of improvement for the Grand and Red Cedar Rivers at Lansing and vicinity found most practical within the limits of economic justification is based on a combined design discharge of 25,000 second-feet which is about 10 percent in excess of the reported maximum flood of record (1904) and about 50 percent in excess of the April 1947 flood. At the stage resulting from this design flood the channels would have a minimum design freeboard of about 2 feet. With the exception of 1 or 2 local areas, for which levees would be provided, the channels would carry a combined flood discharge of about 30,000 second-feet with only minor surface water inundation and limited backwater through sewers and seepage into basements. The principal features of this proposed plan of improvement are as follows:

(a) The existing Red Cedar River channel would be widened, deepened, and straightened from below the College Dam on the Michigan State College campus in East Lansing to its confluence with the Grand River in Lansing to provide flood flow capacity of 8,600 cubic feet per second as far as Sycamore Creek and thence 11,000 cubic feet per second to the Grand River, a total distance of about 5 miles, approximately as follows:

(1) Provide an unlined earth channel about 70-foot bottom width, 1 on 4 side slopes, 16-foot design depth, and 1.5 feet per mile gradient extending for about 17,500 feet from the College Dam to the confluence with the Sycamore Creek. The upper end of this design channel is to be sloped upward to meet the existing bottom grade at the dam. The restricted openings through the Chesapeake & Ohio Railway bridge (College spur) and Harrison Road Bridge are to be riprapped to permit the greater velocity without excessive scour and the still smaller openings of the Athletic Bridge are to be payed with reinforced concrete to prevent scour from high velocities during flood flows.

(2) Provide a channel with 110-foot bottom width, 1 on 4 side-slopes, and 17-foot design depth and 1.0-foot per mile slope extending from the mouth of Sycamore Creek to the Grand River, a total distance of about 8,000 feet. Openings through existing railroad and highway bridges in this reach should be riprapped to prevent erosion.

(3) Clean out and straighten that portion of the Sycamore Creek within Lansing city limits so as to provide better flow condition.

(b) The existing Grand River channel from its confluence with the Red Cedar River in Lansing would be widened, deepened, and straightened downstream to a point about two-thirds of a mile below the North Waverly Road Bridge, a total distance of 6 miles, to provide a flood flow design capacity of 12,400 cubic feet per second including 1,400 cubic feet per second from the Grand River above its junction with the Red Cedar, approximately as follows:

(1) Provide, by means of a general cleaning out, a channel with a bottom width of about 110 feet, 1 on 3 side slopes, 17-foot design depth, and 1.5 feet per mile gradient extending from the Grand-Red Cedar River junction downstream to the Shiawassee Street Bridge, a total distance of about 5,000 feet. Existing side slopes in this reach above the cut will not be disturbed except as noted below and will be paved with about 18 inches of dumped riprap to reduce bank scour. In the vicinity of the new Main Street Bridge it is desirable to widen the channel and to provide 1 on 3 side slopes paved with 18 inches of dumped riprap to prevent bank scour.

(2) Provide an unpaved earth channel of 130-foot bottom width, 1 on 4 side slopes, 17-foot design depth, approximately 1.0 foot per mile gradient extending from the Shiawassee Street Bridge downstream to the North Lansing Dam, a total distance of about 2,100 feet. Existing channel conditions in this reach permit the use of this type of design channel without extensive channel excavation and real estate costs.

(3) Provide an unlined earth channel with 130-foot bottom width, 1 on 4 side slopes, 16-foot design depth, and 1.3 feet per mile gradient extending from the North Lansing Dam downstream to the Seymour Street Bridge,

a total distance of 2,600 feet.

(4) Provide an unlined earth channel having about 280-foot bottom width, 1 on 4 side slopes, 16-foot design depth, and 0.35 foot per mile gradient extending from the Seymour Street Bridge downstream to about two-thirds of a mile below North Waverly Road Bridge, a total distance of about 21,000 feet. Because of the undeveloped nature of the river banks in this area the design of this portion of the channel has been flattened and widened to permit a reduction in grade so that the floodwater will blend into the backwater from the natural channel downstream as soon as possible.

(c) A bypass channel with a design capacity of 13,000 second-feet will be provided between the Grand River in the vicinity of Millett and the Grand River in the vicinity of Delta Mills, a total distance of about 6 miles, approximately as follows:

(1) Provide an unlined earth channel with about 65-foot bottom width, 1 on 4 side slopes, 20-foot design depth, and 1.5 feet per mile gradient extending for about 27,600 feet from the Grand River diversion works to a drop structure. A reinforced concrete head weir and drop structure will be provided at the upper end to permit adequate transition of flow from the pond above the diversion dam to the cutoff channel.

(2) Provide a reinforced concrete paved drop structure with adequate stilling basin to permit a design water surface drop of about 18.4 feet and a channel bottom drop of about 12.4 feet.

(3) Provide an unlined earth channel of 150-foot bottom width, 1 on 4 side slopes, 14-foot design depth, and 1.8 feet per mile gradient for a distance of about 4,300 feet from the drop structure to the Grand River in the vicinity of Delta Mills.

These channel enlargements involving about 9,621,000 cubic yards of excavated materials are based on the following design criteria:

Manning roughness coefficient:

Earth and riprapped channels=0.03

Concrete-lined channel=0.015

Maximum velocities the various channel sections are to be subjected to -

Earth channel=4.0 feet per second

Riprap channel=5.0 feet per second

Through riprapped bridge=6 feet per second

Through concrete paved bridge=8 feet per second

The design depths for these channels have been established to require the least changes in existing bridge foundations, piers, and abutments. Borings and subsurface explorations indicate that this excavation will be entirely in overburden. However, it is possible that there will be a very limited amount of shallow excavation in soft shale near the bottom of the heaviest cut in the cutoff channel.

(d) Riprap channel at critical points to reduce scour.

(e) Pave channel with 8 inches of reinforced concrete and adequate subgrade at critical points to reduce scour.

(f) Construct 4 new highway bridges, 4 new railroad bridges, and 3 highway grade crossings over the Grand and Red Cedar Rivers and diversion channel.

(g) Reinforce substructure, piers, and abutments on 7 highway and 5 railroad bridges over the Grand and Red Cedar Rivers.

(h) Elevate two highway bridges on the Grand River to provide adequate underclearance.

(i) Remove existing buildings and structures from right-of-way.

(j) Clear brush and shrubbery from right-of-way.

(k) Seed side slopes and right-of-way along the entire proposed channel.

(l) Strengthen and extend the low earth levee along the right bank of the Red Cedar River in Lansing Township.

(m) Construct a diversion dam across the Grand River in the vicinity of Millett with the top at elevation 860. This structure would have 1 tainter gate 16 feet high by 25 feet wide, reinforced concrete foundation slab, abutments, core wall and wing walls, baffle piers, and an "Ogee" section concrete spillway, 467 feet in length, with stilling basin and steel sheet pile cutoff walls, and an earth fill nonoverflow section at each end. The sill of the gate section would be approximately at elevation 820.0 and the

crest of the spillway would be approximately at elevation 850.0. At low flow stages in the river the tainter gate would remain open permitting complete discharge down the existing channel. The crest of the Moores Park Dam, located about 3 miles downstream, is at elevation 832.2. As a Grand River discharge of about 4,400 second-feet is reached the tainter gate would be closed and water would pond above the diversion dam to the elevation of the crest of the tainter gate, 836.0, which is also the crest elevation of the diversion weir and floodwater would be diverted down the cutoff channel. As the flow increases the gate would be opened so as to maintain the pool elevation at the top of the gate. At the design discharge, 13,000 second-feet would be diverted down the cutoff channel and approximately 1,400 second-feet would pass through the tainter gate and thence down the existing channel. The backwater elevation above the diversion structure would be at approximately the same elevation as with comparable discharges in the existing channel without diversion. It is considered desirable to provide a concrete spillway section to protect the diversion dam against overtopping by floods equal to the maximum probable flood. At a Grand River discharge of this magnitude (about 62,000 second-feet) flow down the cutoff channel would be about 36,000 second-feet and flow through the open gate and over the spillway section would be about 26,000 second-feet and the water elevation at the dam would be about 5.5 feet below the top of the non-overflow section.

(n) Make alterations to existing water, gas, sanitary and storm sewers, water intakes and electric and telephone lines as necessary for the new and improved channels.

These improvements for flood control will not affect navigation in the area. The only use of the river in this vicinity for navigation is by a few rowboats for recreational purposes. There is no project for navigation improvements and no need or demand for such improvements exists. There is only a limited amount of farming of the river balley plains along the areas to be improved which will receive slight benefit from the proposed plan. The existing dams in the city of Lansing will be retained at their present elevation to impound cooling waters, so no changes will be required to industrial water intakes above these dams along the river. The project will have no effect on hydro power developments on the river. The channel changes involved will have no effect on fish or wildlife. The proposed method of operation with normal flows routed through the existing channel and flood flows bypassed through the proposed cutoff channel will have no significant effect on sanitation.

There is no Federal recreational development connected with this project. No reservoirs are proposed and there will be no additional water areas suitable for development for recreational purposes. It is probable that the city of Lansing and adjacent communities will extend their park system to include most of the right-of-way and other scattered areas along the river channel.

The total cost of the authorized local flood protection project at Lansing, based on July 1971 price levels, is estimated at $29,500,000 of which $22,500,000 would be Federal and $7,000,000 would be non-Federal costs.

The local protection project at Lansing has been placed and is now in the "inactive" category of Corps of Engineers Civil Works projects.

(b) Grandville. A flood control protection scheme for Grandville has been authorized by Congress for construction (House Document No. 51, 88th Congress, 1st session, date 19 September 1963).

The plan selected (Plate Q-37) includes a levee on the right bank of Buck Creek from near Chestnut Avenue to the Interstate Highway 96, which has since been redesignated as I-96. From this point a low levee and impermeable blanket would be placed on the river side of the existing Interstate Highway I-196 embankment from Buck Creek to 28th Street. A third section of levee would extend along the north side of 28th Street from Interstate Highway I-196 to the vicinity of Sanford Avenue and 28th Street. Some of the more important features are:

1. The design water surface elevation of the levees is 608 feet.

2. The average height of the levee embankment is 12 feet.

3. The levee top width is 10 feet, the side slopes are 1 vertical on 2-1/2 or 3 horizontal.

4. The freeboard allowances range from 2 to 4 feet.

5. Closure structures are necessary as street crossings.

6. The gravity outlet and pumping station structure is located along Buck Creek between the C & O Railway and I-196.

The total cost of the authorized flood control project at Grandville, based on July 1971 price levels, is estimated at $2,795,000 of which $2,700,000 would be Federal and $95,000 would be non-Federal costs.

The local flood protection project at Grandville has been placed and is now in the "inactive" category of Corps of Engineers Civil Works projects.

(12) Non-Structural Flood Damage Reduction Recommendations.

Plan B recommends:

a. That local officials implement and enforce necessary regulations in order to provide flood damage reductions during flooding.

b. That authority be granted to the State to implement and enforce necessary regulations if local officials fail to do so in a reasonable length of time in accordance with the State's Shorelands Protection and Management Act (Act 245, Public Acts of 1970).

c. That the Congress provide sufficient funds to carry out existing flood forecasting programs and accelerate the flood hazard and flood plain information programs.

d. That the Federal government carefully consider Federal support of programs which call for the implementaion of non-structural alternatives as methods of reducing and preventing flood damages in the Grand River basin.

g. Upstream Watershed Management

(1) Original Proposals

The U.S. Department of Agriculture conducted an inventory of water management problems in the upstream watersheds throughout the basin. This inventory identified over 725,000 acres in the basin which are damaged by flooding and/or impaired drainage.

Further engineering and economic studies identified fourteen watersheds with potential for development and improvement through the Watershed Protection and Flood Prevention Program (PL-566), as a portion of the Suggested Basin Plan of Development.

An additional twenty six watersheds were identified as having potential for future development. These would be justified primarily through bringing new land into agricultural production, and may become feasible with a growing demand for food and fiber in the future.

The watersheds suggested for early development were Twin Lakes Drain, Freeman Marsh Drain, Huntoon Lake, Perry Creek, Bly Lake, Eaton Rapids, Upper Columbia Creek, Portage River. Prairie Creek, Libhart Creek, Upper Maple River, Hayworth Creek, Stony Creek, and the Rogue River.

These watersheds cover a total area of 949,900 acres, and would provide flood prevention and improved drainage to over 100,000 acres of problem areas. Structural measures include 208 miles of multiple-purpose channel improvement, one single-purpose fish and wildlife structure, and two multiple-purpose flood prevention-recreation structures.

(2) Public Response

The public response to the potential watershed developments has been mixed. Testimony presented at the public hearings held by the Grand River Basin Coordinating Committee was neither strongly critical nor strongly supportive of the watershed proposals in general.

A more positive response developed in the form of official applicationa to the Michigan State Soil Conservation Committee for assistance under provisions of Public Law 83-566. To date, local sponsoring organizations have submitted watershed applications for five of the fourteen potential watershed projects identified in the Suggested Basin Plan of Development. This action indicates that the local people in these watersheds recognize their water management problems and wish to obtain Federal assistance for relief.

(3) Consideration of Alternatives

The USDA watershed Inventory has been thoroughly reviewed to determine possible alternatives to the suggested development program of fourteen watershed projects. Attention was given to possible changes in the scope of the total suggested watershed program as well as modification of specific projects.

First consideration was given to those watersheds with current applications for P.L. 83-566 assistance from local sponsoring organizations. These include Upper Maple River1/, Hayworth Creek2/, Rogue River, Portage River3/, and Stony Creek. In response to the need and the public interest as expressed through the applications, each of these watersheds were included as part of the revised or alternative plan, Plan B.

The remaining watersheds for which applications for P.L. 83-566 assistance have not yet been received were also reviewed. The Soil Conservation Service made informal contacts with several soil conservation districts and drain commissioners in those watershed areas in order to assess current problems and local interest. As a result of these inquiries, Perry Creek and Libhart Creek were included as part of Plan B. While each of the remaining watersheds appears to be economically feasible for development, the current level of local interest is such that they will not be included in the Early Action Program.

Consideration was also given to alternative structural measures within the potential watersheds. Primary attention was given to modifications of channel improvement design and construction methods to minimize possible adverse environmental effects. Engineering studies were also made in each watershed to determine if any structural alternatives to channel improvement were feasible.

1/ Watershed work plans completed and approved by Congress.

2/ Watershed work plan in preparation.

3/ Recent USDA studies indicate that the proposed Portage River project is not economically feasible. Therefore, it is not included as a part of Plan B.

(4) Watershed Protection and Flood Prevention

(a) Introduction

This program provides a project-type approach to soil and water resource development, use, and conservation. Proper land treatment is the basic element of watershed projects, and is considered as the initial increment in project formulation. Structural measures operate in conjunction with land treatment measures to achieve project objectives.

This study has identified 6 watersheds with potential for development within the next 10 to 15 years (Table V-25). These watersheds may be developed if sponsored by qualified units of government. The evaluation of these watersheds was based on the maximum potential devlopment. The scope and purpose of these projects will be dependent upon the desires of sponsoring organizations. The upstream watersheds are delineated on Figure V-25.

(b) Non-Structural Improvements

A program of non-structural improvements is essential to the proper functioning of a watershed project. Land treatment measures will reduce surface water runoff, erosion, and sedimentation which would adversely affect the construction, operation and maintenance of the proposed structural works of improvement.

These measures would be applied through an accelerated program of assistance to watershed owners. This technical assistance would be provided through soil conservation districts by the Soil Conservation Service and the Michigan Department of Natural Resources in cooperation with the Forest Service. This accelerated program would be in addition to conservation programs available under other authorities.

The land treatment measures would be installed by the land owners. The estimated costs are total installation costs and do not reflect cost-sharing assistance which might be available through other programs. The cost of technical assistance for the accelerated land treatment program in the 6 watersheds proposed for early action is shown on Table V-26.

TABLE V-25 SUMMARY OF UPSTREAM WATERSHEDS FOR EARLY DEVELOPMENT (WITHIN 10-15YEARS)

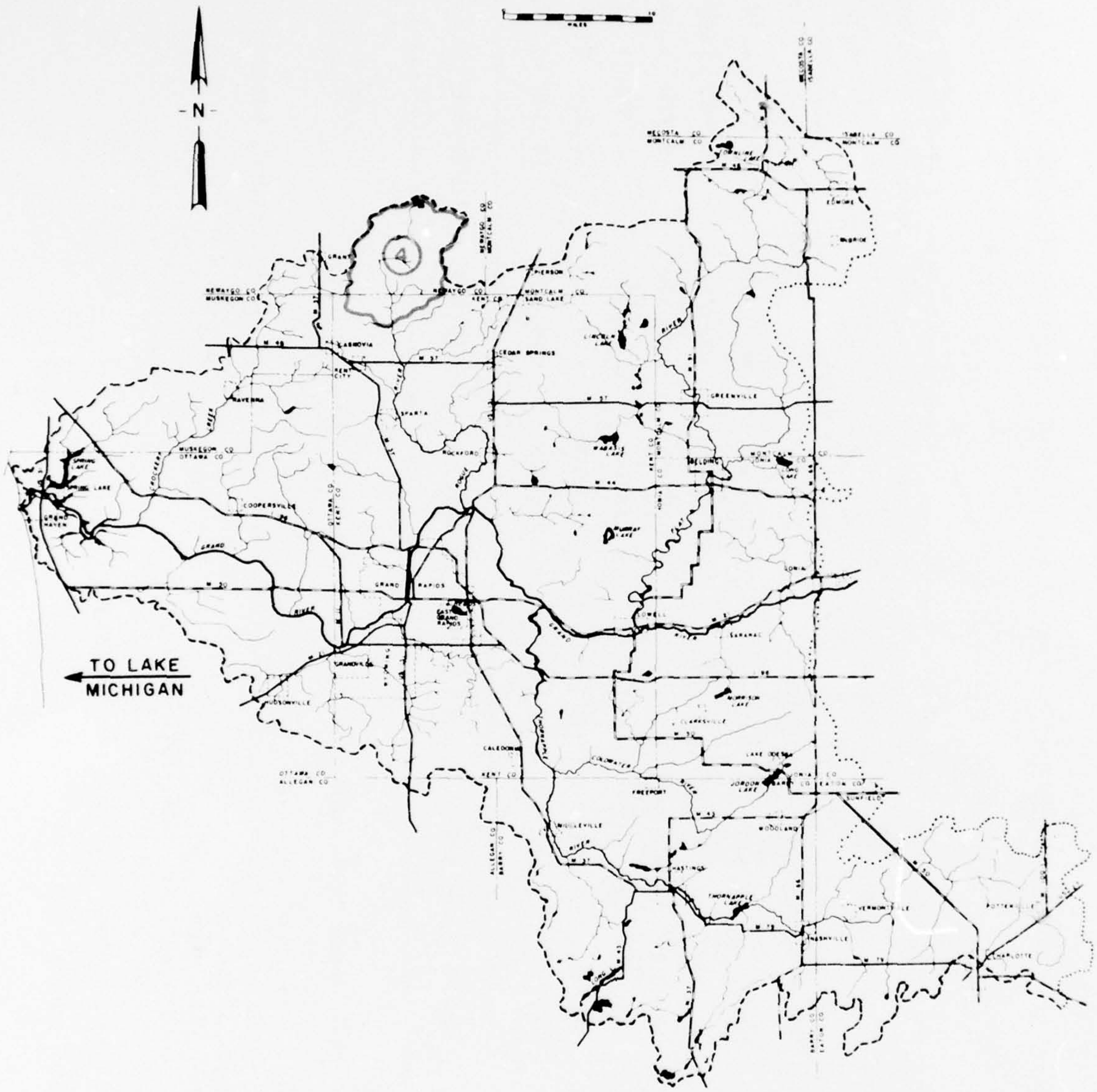
Grand River Basin, Michigan

Watershed	Area	Area Benefited	Channel Work	Structural Installation Cost 1/	Average Annual Cost 2/	Average Annual Beneifts 3/	Benefit Cost Ratio
	(Sq. mi.)	(Acres)	(Miles)		(Dollars)		
Upper Maple River 4/	312.0	28,860	54.2 5/	11,287,400	817,059 6/	2,190,700	2.70:1
Hayworth Creek 7/	104.4	4,430	19.0 8/	3,544,700	198,320	301,780	1.50:1
Stony Creek	178.1	7,245	42.1	1,602,400	103,380	113,720	1.10:1
Rogue River	37.9	3,100	6.3 9/	1,128,000	79,300	88,700	1.12:1
Perry Creek	10.4	3,251	5.3	210,600	13,100	14,400	1.10:1
Libhart Creek	17.1	1,676	8.4	256,200	16,300	17,300	1.06:1
TOTAL	659.9	48,562	135.3	18,029,300	1,218,459	2,726,600	2.24:1

1/ Price Base: 1970.
2/ Includes O & M, and Installation cost amortized for 50 years at 5 3/8%.
3/ Price Base: Adjusted normalized.
4/ Data from PL-566 Watershed Work Plans, July, 1969; approved by Congress 1971.
5/ In addition, plans include one multiple purpose structure, one single purpose structure, 14.4 miles of dike, and four pumping stations.
6/ Amortized at 4 7/8% per work plan.
7/ Data from PL-566 Watershed Work Plan, June 1971 draft.
8/ In addition, plans include one multiple purpose reservoir.
9/ In addition, proposal includes one dike and pumping station.

Note: Land treatment costs are not included.

LOWER GRAND RIVER BASIN



UPSTREAM
WATERSHEDS

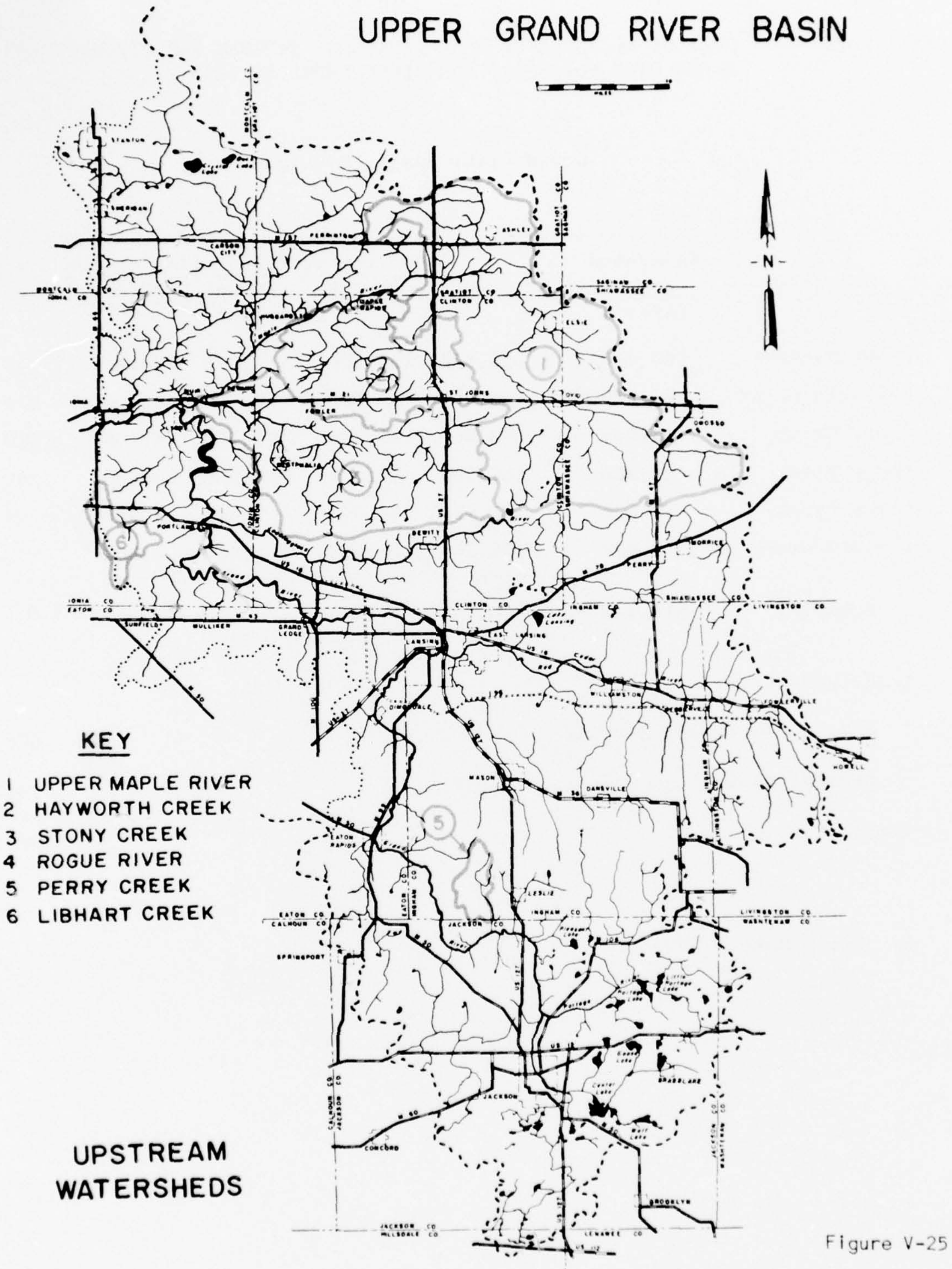

UPPER GRAND RIVER BASIN
N
KEY
1 UPPER MAPLE RIVER
2 HAYWORTH CREEK
3 STONY CREEK
4 ROGUE RIVER
5 PERRY CREEK
6 LIBHART CREEK
UPSTREAM WATERSHEDS

Figure V-25

TABLE V-26 COST OF ACCELERATED LAND TREATMENT PROGRAM FOR SIX UPSTREAM AREAS WITH POTENTIAL FOR DEVELOPMENT BY 1985

Grand River Basin, Michigan

Watershed	Watershed Area	Land Treatment Installation Cost 1/				
		Cropland	Pasture	Forest	Misc.	Total
	(Acres)	(Dollars)				
Upper Maple	195,460	1,342,800	107,900	17,500	20,100	1,488,300
Hayworth Creek	66,810	266,900	31,500	2,600	9,700	310,700
Stony Creek	113,984	1,373,500	145,900	36,100	64,200	1,619,700
Rogue River	24,256	267,300	52,300	26,900	13,700	360,200
Perry Creek	6,656	73,400	14,000	3,400	3,700	94,500
Libhart Creek	10,944	124,200	23,600	5,400	6,200	159,400
Subtotal	418,110	3,448,100	375,200	91,900	117,600	4,032,800
Technical Assistance						
Soil Conservation Service						675,000
Federal-State Cooperative Forestry						162,000
Total						4,869,800

1/ Price Base - 1967

(c) Structural Improvements

Normally, not all watershed needs can be met solely by land treatment. Problems such as flooding and impaired drainage usually require structural measures for adequate relief. In the watershed program, waterflow control measures are planned to operate as a system in conjunction with land treatment measures.

Floodwater retardation is the primary consideration in designing a system of waterflow control measures. Channel modification, floodways, or diversions are considered supplementary to floodwater retardation except where necessary to achieve project objectives at a reasonable cost.

The nature of the flooding and drainage problems which affect existing agricultural land in the basin, as well as the general lack of adequate floodwater retention sites, require that channel work be utilized for waterflow control. All channel work will be installed according to current Soil Conservation Service criteria and revised construction techniques designed to minimized adverse environmental impacts. These features include: Sediment basins to prevent downstream sedimentation during construction; daily seeding and revised velocity criteria to assure channel stability; minimum clearing, selective spoil placement, and where appropriate, excavation from one side of the channel to maintain existing vegetation to the greatest possible extent; establishment of berms, seeding, and selective shrub plantings where appropriate to provide wildlife habitat. Alternatives to channel work have been considered, and will be thoroughly studied in the detailed planning stage where they would be engineeringly and economically feasible, and consistent with project objectives.

Structural measures in the 6 potential watersheds include 135.3 miles of multiple-purpose (flood prevention and drainage) channel work; one single-purpose flood prevention structure; and two multiple-purpose structures.

The installation cost of these proposed structural measures within the 6 potential watersheds is estimated to be $18,029,300 (Table V-25). Under provisions of the Watershed Protection and Flood Prevention Act (P.L. 83-566), qualified sponsors would be eligible for technical assistance for the design, and cost-sharing assistance for the construction, of these structural measures.

(d) Summary of Watersheds Suggested for Development

1. Upper Maple River

This watershed drains 312 square miles (199,680 acres). The watershed has already been authorized for Public Law-566 planning. A watershed work plan was prepared in August 1969, and recently approved by Congress. The Soil Conservation Districts and County Drain Commissioners of Clinton, Gratiot and Shiawassee Counties, the Maple River Inter-County Drainage Board, and the Michigan Department of Natural Resources are the sponsors. There are flooding and inadequate drainage problems on 28,860 acres (24,470 acres of mineral soil and 4,390 acres of organic soil). Flooding is the primary problem on 16,500 of the 28,860 acres.

Two structure sites are proposed. One is single-purpose flood prevention site located on Bear Creek. This site, structure 109, was originally proposed for multiple-purpose use with a permanent recreation pool. Recent discussions and agreements between the local sponsoring organizations and the Soil Conservation Service have determined that a single-purpose flood prevention structure will best meet local needs.

Structure 110, located on the Little Maple River, will provide both flood water retention and recreation. It will have a recreation pool of 412 surface acres. The primary activities would be swimming, picnicking, camping, boating, hiking, field sports, and nature study. Peak daily use is estimated to be 20,500 visitors. These developments, located in the Lansing Subarea, would fill a need for water-related outdoor recreation facilities in the area of greatest demand.

For drainage and flood control, 14.4 miles of channel work with levees, and four pumping stations with collection ditches are proposed. A 25.9 mile multiple-purpose (flood prevention and drainage) channel extending from the upper portion of the Maple River to approximately one mile below the village of Duplain, and 13.9 miles of multiple-purpose channels on the main stem tributaries, are also proposed. Works of improvement for the main stem of the Maple River below Bannister would include

14.4 miles of channel improvements with levees to provide a floodway from Bannister to U.S. Highway 27. Four electric-driven pumping stations with collection ditches would be located in the area to pump water from adjacent areas into the floodway. Watershed development would provide flood damage reduction, drainage, and recreation benefits.

2. Hayworth Creek

This tributary to the Maple River drains 104.4 square miles (66,810 acres) of Clinton County. The area lies in the Clinton County Spoil Conservation District, and has flooding and inadequate drainage on 4,382 acres (2,432 acres of mineral soil and 1,950 acres of organic soil). The watershed is currently authorized for Public Law 566 planning. Project sponsors are the Clinton County Soil Conservation District, Clinton County Drain Commissioner and the Michigan Department of Natural Resources.

Recent investigations have led to the proposal of a multiple-purpose (flood prevention-fish and wildlife) structure on Hayworth Creek. This will provide 452 acres of permanent water surface for fish and wildlife habitat development. Fishing, hunting, and related activities will be available.

Other works of improvement needed for the watershed consist of approximately 19 miles of multiple-purpose channel improvement. Watershed development would provide flood damage reduction, drainage, and fish and wildlife benefits.

3. Stony Creek

This wafershed drains 178.1 square miles (113,984 acres) of Clinton and Ionia Counties. The area is primarily in the Clinton County Soil Conservation District. The soil conservation districts and drain commissioners of Clinton and Ionia Counties have submitted an application for assistance under Public Law 566.

There are flooding and inadequate drainage problems on 8,245 acres (7,221 acres of mineral soil and 1,024 acres of organic soil). Flooding is the primary problem on 2,227 acres. The works of improvement needed for the watershed are 42 miles of multiple-purpose channel improvement. In the detailed planning stage, consideration will be given to possible structure sites which have been suggested by local interests.

4. Rogue River

This watershed drains 37.9 square miles (24,756 acres) of Newaygo and Kent Counties, and has inadequate drainage and flooding on 3,100 acres of fertile organic soil. Works of improvement are needed primarily in the Newago Soil Conservation District. The Newaygo County Soil Conservation District, Northwest Kent Soil Conservation District, Newaygo County Drain Commissioner, and Kent County Drain Commissioner have submitted an application for assistance under Public Law 566.

Due to the flat topography of the watershed, there is no possibility of using structures for floodwater retardation. High-valued vegetable crops such as onions, red beets, and carrots are grown. Channel improvement was originally proposed for 10.6 miles on the Rogue River and tributaries. It is now proposed that channel improvement be confined to approximately 11.8 miles primarily in the benefit area, and that a dike and pumping station be installed on the Rogue River immediately upstream from Costen Drain. This would eliminate approximately 2.5 miles of channel improvement on the Rogue River and prevent possible adverse effects within the Rogue River State Game Area.

5. Perry Creek

This watershed has a drainage area of 10.4 square miles (6,656 acres) in Ingham County. The area lies in the Ingham Soil Conservation District. An application for assistance under Public Law 566 has not yet been received. It has flooding and inadequate drainage on 3,251 acres (1,536 acres of mineral soil and 1,715 acres of organic soil). The flat topography of the watershed precludes the use of flood water retarding structures for flood prevention. The watershed needs 5.3 miles of channel improvement. Watershed development would provide both flood damage reduction and drainage benefits.

6. Libhart Creek

This watershed is at the upper end of Libhart Creek, a tributary to the Grand River. The watershed drains 17.1 square miles (10,944 acres) in the Ionia County Soil Conservation District. An application for assistance under Public Law 566 has not yet been received. Flooding and inadequate drainage occur on 1,676 acres (1,039 acres of

mineral soil and 637 acres of organic soil). The flat topography of the watershed eliminates the possibility of structures for floodwater retardation; channel improvement is needed on 8.4 miles of channel. Watershed development would provide both flood damage reduction and drainage benefits.

(e) Post 1985 Watershed Development

Investigations identified 35 watersheds with potential for future development (Table V-27). Further studies are dependent upon expression of local interest. Six of these watersheds are economically feasible feasible under current criteria. The remaining would be justified primarily through bringing new land into agricultural production, and may become feasible with a growing demand for food and fiber in the future.

TABLE V-27 Summary of Upstream Watershed Areas With Potential For Future Development Grand River Basin, Michigan

Watershed Name	Watershed Areas (Sq. Mi.)
Twin Lakes Drain 1/	5.4
Freeman Marsh Drain 1/	8.0
Huntoon Lake 1/	11.6
Bly Lake 1/	11.7
Eaton Rapids 1/	13.6
Upper Columbia Creek 1/	18.3
Prairie Creek 1/	46.0
Snyder & Wheeler Drain	9.2
Rives Junction	8.0
State	4.0
Berry Lake	2.7
Pleasant Lake	5.3
Whitney Drain	3.8
Leslie	7.5
Darling Christie Drain	4.5
Lanes Lake	4.7
Willow Creek	16.6
Sandstone Creek	31.6
Tompkins	6.8
Spring Brook	35.3
Bateese Creek	18.0
Upper Cedar River	20.1
Winegar	5.7
Middle Cedar River	28.7
Randal	3.4
Grant	4.8
Brown	4.8
Mud Creek	28.3
Lookingglass River	187.0
Pewamo	7.5
Penny Creek	18.9
Hemingway Lake	2.2
Black Creek (Montcalm & Kent)	45.6
Buck Creek	51.2
Plaster Creek	60.4
TOTAL	741.2

1/ Recommended as part of Early Action Program in Plan A.

h. Land Treatment and Other Non-structural Programs

(1) Original Proposals

A comprehensive, accelerated land treatment program and soil survey program was suggested to reduce runoff, erosion, and sedimentation, and to provide for improved land management. The suggested program was based on the Michigan Inventory of Soil and Water Conservation Needs (CNI), and included three major aspects.

First was a land treatment program within the fourteen potential watershed projects. This would provide adequate treatment to a total area of 148,600 acres at an estimated cost of $7,763,500, including $6,771,800 for installation and $991,700 for technical assistance.

The second phase would be applied within the drainage area of the proposed multiple-purpose reservoirs. This program would provide adequate treatment for 332,600 acres at an estimated cost of $18,572,000.

The third portion would be a program of environmental enhancement in urban and built-up areas through soil, forest, and water conservation. This $1,400,000 program would provide technical assistance in formulating and implementing effective land use plans.

The fourth proposal was an accelerated soil survey program. This would provide complete up-to-date soils information to help guide land use decisions throughout the Basin. This $751,000 program would cover over 1.1 million acres.

(2) Public Response

Public response to the land treatment program has been favorable. The concept of reducing runoff and erosion at its source and providing environmental enhancement through appropriate land treatment measures is accepted throughout the Basin.

(3) Consideration of Alternatives

That portion of the accelerated land treatment program which was suggested for application within the fourteen potential watersheds was thoroughly reviewed. Since the scope of the watershed program has been reduced, consideration was given to reducing this phase of the land treatment program. A review was also conducted of the suggested land treatment program within the drainage area of the originally proposed multiple-purpose reservoirs.

The Michigan CNI indicates that by 1985, additional land treatment measures will be needed on 1,471,000 acres of crop, pasture, forest, and other land within the Basin. Current Soil Conservation Service programs and the cooperative Federal-State forestry programs. If continued at present levels, would provide adequate treatment for a total of 183,000 acres by 1985, or just 12 percent of the total 1985 needs.

If the accelerated land treatment program is completed in the six potential watersheds, an additional 88,000 acres will be adequately treated by 1985. Together with current programs this would provide for a total of 308,000 acres, or only 21 percent of the total 1985 needs. It is clear that a more comprehensive land treatment program is needed.

(4) Land Treatment

Land treatment measures for watershed protection will be needed on 1,471,000 acres of crop, pasture, forest, and miscellaneous land within the Basin by 1985. In order to help meet these needs, it is recommended that the current Soil Conservation Service and soil conservation district programs and the cooperative Federal-State forestry programs be continued at the present levels of accomplishment. These programs will provide adequate treatment for 145,000 acres of cropland, 15,000 acres of pasture land, 20,000 acres of forest land, and 3,000 acres of miscellaneous land. This represents a total of 183,000 acres, or 12 percent of the total 1985 needs.

In order to more fully meet total 1985 needs, a 10-year accelerated land treatment program is recommended. This program will apply the necessary treatment on an estimated 444,200 acres, or 33 percent of the total Basin needs. The cost of this program is estimated to be $24,643,000. One portion of this accelerated program will be implemented within the proposed upstream watershed areas. This program will provide adequate treatment of 88,000 acres at an estimated cost of $4,869,800. It will accomplish 74 percent of the remaining 1985 needs within these watersheds.

The other phase of the accelerated land treatment program will be applied throughout the Basin as a whole. This program, to be implemented through Soil Conservation Service and soil conservation district programs, and Cooperative Federal-State forestry programs, will provide adequate treatment for 356,200 acres at an estimated cost of $19,773,200.

Figure V-26. Plan B provides for land treatment measures to be carried out in the basin to enhance crop, pasture, forest, and miscellaneous lands.

Conservation treatment measures will include (1) water control measures such as terraces, waterways, and field diversions; (2) measures to protect the soil from erosion and increase infiltration rates such as strip cropping, contouring, cover stripping, minimum tillage, revegetation, and crop residue management; (3) farm drainage systems; (4) farm ponds; (5) gully control measures; and (6) improved forest land management.

(5) Environmental Enhancement in Urban and Built-Up Areas Through Soil, Forest, and Water Conservation

A technical assistance program for urban areas is recommended in order to protect soil and water resources, and to provide an opportunity for man to live in harmony with his natural environment. These goals may be achieved through proper land use planning designed to reduce soil erosion, help maintain water quality, reduce flood damages, improve vegetative cover, and enhance natural beauty. This program will provide assistance to planning boards, community leaders, and developers in formulating and implementing effective land use plans.

Proper interpretation of soil surveys will be provided to indicate the best development sites, and to help avoid problems of poor drainage, unstable soils, and severe erosion hazards. Recommendations for good land use will include methods of controlling excessive erosion which occur despite the most conscientious application of protective measures, the goal will be to prevent controllable erosion and keep sediment production to a minimum. This will not only protect the development site itself, but also prevent sedimentation and degradation of surface waters. Since much of the most favorable land is already developed, the use of soil surveys and soil conservation practices will become even more important in the future.

Pressures for floodplain use will increase with expanding population and continued economic growth. Future flood damages will be minimized only by plans and policies which recognize existing and potential flood hazards. Technical assistance will be provided to identify floodplain areas, and to aid in the development of prudent floodplain management programs.

Vegetative cover, including trees, schrubs, and grasses, should be established, retained, or improved in the metropolitan areas to provide natural beauty, recreation opportunities, and enviromental enhancement. This program will furnish technical assistance for the development and maintenance of forest, nature areas, parks, open spaces, buffer zones, and greenbelt areas.

Assistance will include the identification and location of suitable areas to be retained for: (1) Community and school forests - to provide areas for aesthetics, recreation, and outdoor classes involving nature study and conservation education; (2) Vegetated buffer zones or screening strips - to isolate housing or industrial developments and for highway beautification; (3) Infiltration zones or sediment traps along waterways and roads - to retard surface runoff, erosion, and sedimentation; and (4) Forest areas in valley preserves - to provide areas for recreation, wildlife habitat, and aesthetics. Advice will be available to improve tree stands and plant development to enhance recreation opportunities, wildlife habitat, nature studies, and sylvan aesthetics. Technical services will be provided for the control of insects, plant diseases, non-structural fires, animal damage, and pollutants in forests, parks and greenbelt areas.

The program should be a local - State - Federal cooperative program involving the U.S. Department of Agriculture, the State of Michigan, Soil Conservation Districts, and other local units of government.

It is recommended that a 10-year, $800,000 urban soil and water conservation program be initiated to meet problems of poor land use and erosion in urban areas throughout the Basin. This program will be implemented through the Soil Conservation Districts in cooperation with the Soil Conservation Service.

It is recommended that a 10-year, $600,000 urban and community forestry assistance program be initiated in the Grand River Basin with emphasis placed on the Grand Rapids and Lansing areas. The Forest Service will be assigned leadership in the forestry program in cooperation with the Michigan Department of Natural Resources.

(6) Accelerated Soil Survey

Soil surveys have been used to guide land use and management decisions on farms and in forests for many years. These same principles of managing soil and water can be applied to urban development problems. The soil survey describes soil limitations for building sites, onsite sewage disposal, road construction, recreation development, and other uses. It may also be used to locate potential sediment source areas, and as a tool for flood plain delineation.

Completed and currently programmed soil surveys cover eleven of the twenty counties with acreage within the Basin. The Soil Conservation Service is conducting soil surveys for conservation planning in the remaining nine counties. This level of survey activity will not be sufficient to provide for all of the needs of the expanding urban areas.

An accelerated program is recommended which will complete the soil survey throughout the Basin by 1985. A total area of 1,172,800 acres will be surveyed through the National Cooperative Soil Survey at an estimated total cost of $751,000. Early emphasis should be given to expanding the Grand Rapids and Jackson areas.

(7) Water Quality Monitoring of Agricultural Pollutants in Upstream Areas.

Environmental pollution is recognized as a problem in the Grand River Basin. Programs for improving environmental quality must aim at preventing further deterioration and at restoring the quality to a socio-economically acceptable level. Accurate information on the sources of environmental pollution is a prerequisite to planning effective improvement programs. At the present time, sufficient data regarding pollutants in upstream watersheds are lacking.

A compresive 15-year program for water quality monitoring of agricultural pollutants in upstream watersheds is recommended. This cooperative program would monitor sediment, bacteria, nitrates, phosphates, chlorides, and other pollutants discharged as a result of agricultural production processes for the 15-year period. In addition, comprehensive sur-

veys of soil and land use conditions, fertilizer and pesticide application, and livestock population would be conducted in the watershed areas upstream from the monitoring points. This will provide information on land management conditions as they affect quanties of various pollutants carried in surface waters.

This program could be implemented by the Soil Conservation Service and other USDA agencies in cooperation with the Michigan Water Resources Commission at a total cost of $630,000. Costs could be shared by the Federal government and by non-Federal interests.

(8) Post 1985 Land Treatment and Other Nonstructural Program

Continuation of the accelerated land treatment program is recommended. Through this program, it is estimated that 85 percent of the land treatment needs would be satisfied by 2020. One portion of this program would be applied within the watersheds which may be developed. The other portion would be applied in the remainder of the Basin.

Continuation of the technical assistance program for urban areas is recommended. Results of accomplishments during the Early Action Program would be reviewed in order to prepare a detailed program and budget estimates.

Review and evaluation of the agricultural monitoring program is recommended at the close of the initial 15-year period. Data collected and analyses completed to that date would be reviewed to determine future program activities and funding levels.

1. Electric Power

The Grand River Basin is currently an importer of electric energy and it is expected to continue to be during the period covered by this report. Consumers Electric Power Company, the principal supplier in the Basin, has no plans to build future power plants in the Basin. Power is imported from its Campbell plant on Lake Michigan and will be imported from other plants located on Lake Michigan. The only expansion planned within the Basin is the third steam-electric power plant of the Lansing Board of Water and Light, located in Delta Township, Eaton County. This plant is planned with an ultimate capacity of 1500 MW. The first unit of 160 MW is scheduled for commercial operation in 1972. The plant will have cooling towers and a water supply pond as described in Plan A.

Undeveloped hydroelectric power potential as shown in Plan A is estimated to be about 18,700 kW and with an estimated average annual energy of about 78.4 million kWh. The economic feasibility of this potential has not been established.

As indicated above, additional electric power demands in the Grand River basin can be met by drawing from sources located outside of the basin. As a consequence, Plan B includes no provisions for increasing the overall capacity of electric power plants in the Grand River basin to meet future needs.

j. Navigation. The existing and future utilization of the Grand River in the interest of recreational and commercial navigation is being investigated. Studies include an analysis of existing navigation projects and their relationship to present and prospective commerce and vessel traffic, and investigations to determine the desirability of modifying existing projects or providing additional improvements for both commercial and recreational navigation. It is concluded, based on the limited information available, that further improvement of Grand Haven Harbor and the lower reach of the Grand River to the Bass River for commercial navigation and improvement of the Grand River up to Grand Rapids for recreational navigation (see Figure V-27) appear to have some economic justification and be worthy of further detailed study.

Detailed study of the commercial improvement is presently underway in accordance with a study authorized by a House Public Works Committee Resolution adopted 1 March 1950. Significant features of a preliminary plan of improvement are described in Appendix I, Navigation, of the Grand River Basin Study Report, and in Section IV, pages IV-15 thru IV-25, herein. Estimated savings in freight costs that could be realized if the improvements included in the preliminary study plan are provided are given in Tables IV-4a and IV-5 herein. The total cost of providing these improvements has not been established.

Another study authorized by a House Public Works Committee Resolution adopted 9 April 1957 will cover the recreational boating aspect of navigation on the Grand River. A preliminary study plan of improvement is also described in Section IV herein and in Appendix I. The total first cost of providing the improvements included in the preliminary study plan is estimated to be $2,500,000, based on July 1968 price levels. The average annual maintenance cost is estimated at about $60,000, based on previous experience gained in connection with the existing Federal project on the Grand River between Grand Haven and Bass River. The total annual charges, including cost of maintenance, would amount to approximately $160,000. Preliminary investigations indicate that such a project on the Grand River for recreational navigation would be economically feasible.

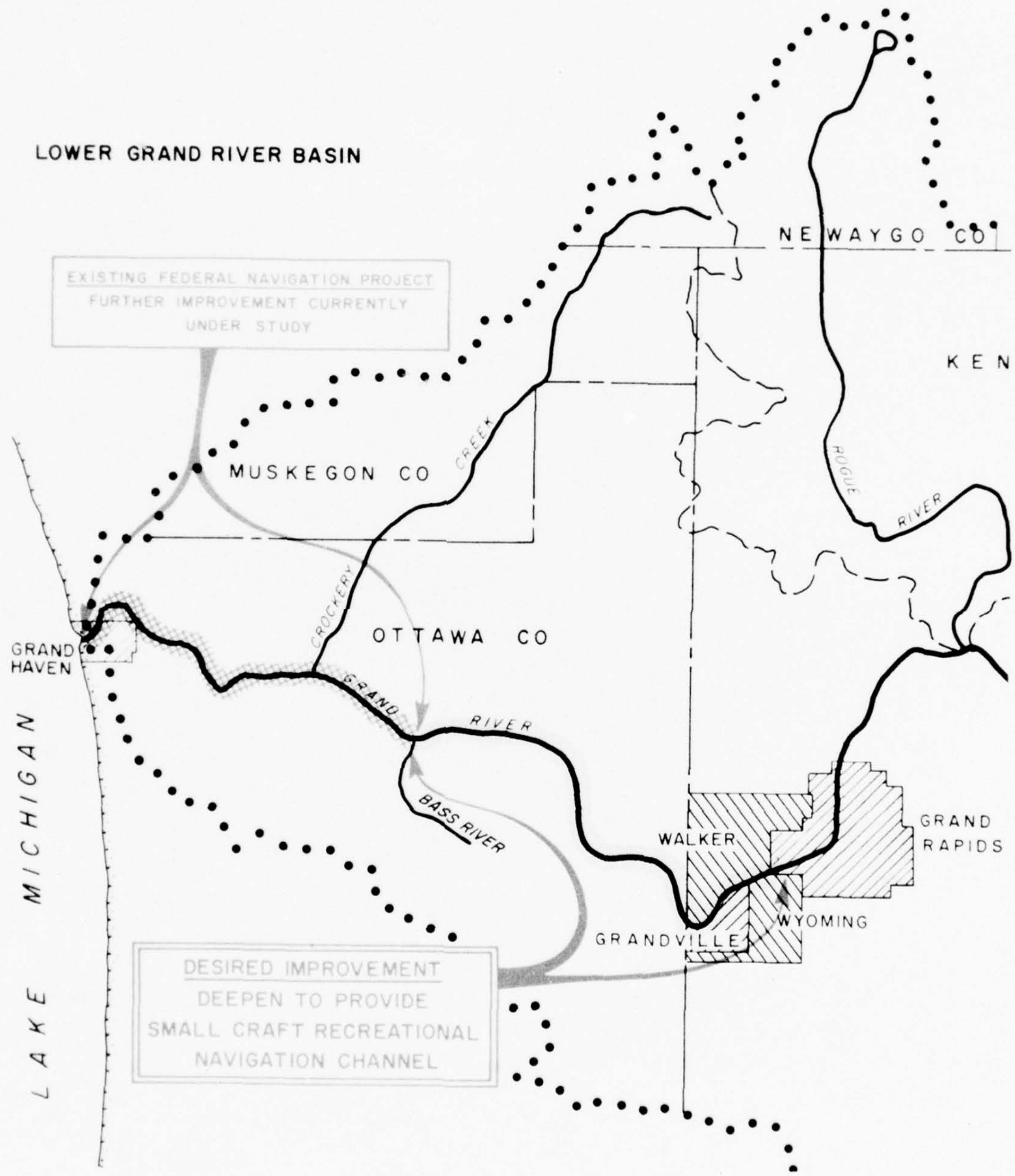
These two authorized studies are expected to provide sufficient data for determining the economic feasibility of further improving the Grand River for both commercial and recreational navigation.

The following uses of the Grand River appear compatible with other designated and planned uses. Thus, providing appropriate studies are coordinated to determine economic justification, the extent of Federal interest and the applicability of cost-sharing, and other factors, Plan B with respect to commercial and recreational navigation indorses provisions for:

(1) Improving Grand Haven Harbor in the interest of commercial navigation by deepening the existing channel to provide a controlling depth of 25 feet and enlarging the turning basin.

(2) Improving the Grand River channel from Grand Haven to the Bass River in the interest of commercial navigation by widening the existing project channel to 125 feet in the straight reaches and 150 feet at the bends, and possibly increasing the project depth.

(3) Improving the Grand River in the interest of recreational navigation from the Bass River to Grand Rapids, a distance of about 23 miles, by providing a channel 5 feet deep and 100 feet wide.



GRAND RIVER BASIN MICHIGAN
NAVIGATION STUDIES

EXISTING AND DESIRED IMPROVEMENTS

FIGURE V-27

SECTION VI

SUMMARY OF PLAN B RECOMMENDATIONS

1. Water Quality in the Grand River Basin

Following are Plan B recommendations for water quality enhancement in the Grand River basin.

Plan B recommends:

a. That the State's ongoing Interim Water Quality Management Plan, in effect throughout the Grand River basin, be implemented. Implementation of the plan will be in accordance with the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), administered by the U.S. Environmental Protection Agency, and will include:

(1) Continuing improvement of the State's water quality management program with provisions for the Federal government to provide up to 50 percent of this cost.

(2) Following the recommendations of and providing the required facilities as indicated in the basin water quality management plan.

(3) The State and local units of government taking such actions as necessary to eliminate the problem of pollution due to stormwater runoff from combined sewers.

b. That the Federal government, on a timely basis, provide financial assistance to the State and its local units of government to help implement the plan under current cost sharing arrangements. The current Federal share of the total cost of local wastewater treatment facilities is 75 percent. The estimated cost to implement the State's Interim Water Quality Management Plan from 1970 to 1975 is $50,000,000; from 1975 to 1980, $50,000,000; and from 1980 to 1985, $50,000,000.

c. That Sections 402 and 404 of P.L. 92-500 regarding discharge permits be enforced. Under Section 402 of P.L.92-500, no discharge from any point to navigable waters is allowed without a permit issued by the State, subject to review and concurrence by the Environmental Protection Agency. Section 404 of P.L. 92-500 authorizes the Corps of Engineers to issue permits for the disposal of dredged or fill material to navigable waters at specific

disposal sites subject to review and concurrence of the Environmental Protection Agency.

d. That the Michigan Water Resources Commission's existing programs to prevent and correct unlawful industrial discharges be enforced.

e. That an applied research program costing an estimated $2,000,000, be instituted to investigate the applicability of advanced and currently experimental waste treatment processes including land disposal for the Grand River basin, to meet post 1985 water quality needs.

2. <u>Water Supply</u>

Water supply investigations conducted in connection with the Grand River Basin Study indicate that communities in the basin are not expected to experience any serious water supply shortages within the next 10- to 15-years and not until about the year 2000. Consequently, Plan B includes no recommendations in regard to enhancing water supply resources in the basin to meet future needs.

3. <u>Valley Preservation and Recreation</u>

a. <u>Valley Preservation</u>

The valley preserve system Plan B has adopted, if implemented, would: (1) preserve features of the flood plain worthy of being preserved in their natural state; (2) provide flood plain areas for low key recreation (hunting, fishing, hiking, and picnicking); and (3) prevent buildings and other facilities, which would be subject to major flood damages, from being erected within the flood plain.

Plan B recommends:

That a valley preserve system be implemented by the State of Michigan on the following streams as described below.

(1) The Grand River downstream from the mouth of the Portage River.

(2) The Red Cedar River downstream from the west city limit of Williamston.

(3) The Lookingglass River downstream from the west city limit of Dewitt.

(4) The Maple River downstream from the east boundary of the Maple River State Game Area.

(5) The Flat River downstream from the east boundary of the Langston State Game Area.

(6) The Rogue River downstream from the north boundary of the Rogue River State Game Area.

(7) The Thornapple River downstream from the west city limit of Nashville.

(8) The Coldwater River downstream from the outlet of Jordan Lake.

Implementation of the valley preserve system would proceed in four steps: (1) designation; (2) zoning; (3) provision of public access; and (4) development of public use. Lands or interest in lands would be acquired only with the consent of the owner. The valley preserve system would consist of approximately 450 miles of river frontage along the above streams as indicated on Figure V-7, page V-83.

b. Recreation

Plan B recommends that the nine recreation nodes, described in Section V, comprising a total of approximately 20,000 acres be implemented by the State of Michigan within the 1975 thru 1984 time frame. The nine nodes would be in concert with the valley preserve system and would also provide for low key recreation.

c. Benefits and Costs

It is estimated that total visitation to recreation activities, initially, would approach 2,194,000 recreation days. Ultimately, total visitation is expected to approach approximately 5,544,000 recreation days.

Total cost of the two programs is estimated at $70,716,000 (see Table V-18). Total recreation average annual benefits* are estimated at $3,410,000; total average annual costs are estimated at $3,663,000.

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*It is estimated that up to 25 percent of the basin's rural flood damages could be prevented between 1974 and 1984 by implementing the Valley preserve system.

4. Fish and Wildlife

The major thrust of the fish and wildlife program included in Plan B is toward the preservation and wise use of the Grand River basin with the objective of providing a mix of the natural scene with modest recreational facilities. A well planned and coordinated program could provide maximum use of basin resources while maintaining it in a natural and aesthetically pleasing condition. Both the hunter and non-hunter will profit. The following recommendations are aimed at providing the maximum use.

Plan B recommends:

a. That the on-going acquisition program of State game lands be maintained to 1975 as projected by the Wildlife Division of the Michigan Department of Natural Resources.

b. That an accelerated program of acquisition of the 70,000 acres of land needed to meet the State's goal acreage for the 19 State game areas in the basin, be initiated not later than 1975 and be completed by 1985. At least 85 percent of the estimated cost of $14,000,000 could come from Federal sources.

c. That the State's intensified on-going warmwater and trout fishery program for controlling rough fish populations in trout waters and the lake and stream reclamation program be continued.

d. That the valley preserve program for providing access be implemented immediately so that the full benefits of the intensified on-going fisheries program and the developing anadromous fishery program can be realized.

e. That the combination of fish passage and dam removal program described in Section V be implemented not later than 1973 starting with the Grand Rapids dam and working upstream.

f. That top priority be given to implementation of the Interim Water Quality Management Plan for the basin so that the fishery benefits associated with recommendations "c", "d", and "e" can be realized.

g. That private conservation organizations as well as all levels of government be encouraged to acquire or control and preserve unique areas and valuable fish and wildlife habitat.

h. That the Water Bank Program (P.L. 91-599) of the Agricultural Stabilization Conservation Service be implemented not later than 1973 with first priority being given to those wetlands where a conflict exists between

agricultural practices and the management and use of these areas for fish and wildlife purposes.

i. That tax relief, cost sharing programs, easements, and other means be devised and legislation passed if necessary to provide monetary incentives to landowners to manage their land for fish and wildlife purposes.

j. That a Federal grant program be instituted making funds available to qualified biologists (to either individuals or to agencies) to study and survey the wetlands and factors related to the Greater Sandhill Crane breeding grounds known to exist in the basin with special emphasis on the Portage Lakes region.

k. That consideration be given to some type of user fee for public lands where one interest is supporting use by other interests; e.g., State game areas are financed with fishing and hunting fees but are used by many non-sportsmen.

l. That a special wetlands fund be established from both State and Federal sources to provide for the acquisition, or lease of productive wetlands identified in the study and cited in recommendation "p" below.

m. That consideration be given to the establishment of a major State-Federal private agency with responsibilities to manage waterfowl, Greater Sandhill Crane, and aquatic animals in the Portage Lakes region.

n. That legislation be enacted or existing laws be implemented to prohibit the dredging, filling and altering of wetlands by both private and public agencies without a permit from the State.

o. That 10,000 acres of the 31,000 acres of stream associated wetlands delineated on the fish and wildlife map be acquired by the State. This is in addition to those wetlands acquired incidental to the valley preserve program or as part of the goal acreage for the State game areas.

p. That the State complete, not later than 1973, an inventory of the extent and quality of the wetlands in the basin so that this information can be used in wildlife management planning.

TABLE VI-1

RECOMMENDED FISH AND WILDLIFE PROGRAMS

PROGRAM			COST	NET BENEFITS
a. Ongoing acquisition	1970-1975	6,060 Acres	$663,000	2990 Hunter Days 6270 Non-hunter Days
b. Goal Acreage acquisition (Two million dollars per year; one million State, one million Federal grant-in aid).	1970-1985	70,000 Acres	$14,000,000	63,000 Hunter Days 189,000 Non-Hunter Days
c. Ongoing fishery	1971-1975			36,000 Fishing Days (Warmwater and Trout) 100,000 Fishing Days (Anadromous)
e. Fish passage and dam removal (Costs include annual O & M. Total O & M includes portion of that for fish passage structure).	1973-1985	17 Dams	$335,000 (Fish Passage) $515,000 (Dam Removal)	275,000 Anadromous Fishing Days Smallmouth bass fishing days
h. Water Bank (PL 91-559) (A new program. Provides 10-year lease agreements to landowners who agree to preserve their wetlands. Amount of lease can be increased if owner agrees to public hunting, trapping, fishing and hiking. 100 percent Federal funds).	1973-1985	Acres	$600,000	Aquatic animal production Fish and Wildlife recreation
j. Sandhill Crane Study (A two year study leading to recommendations for management) (100 percent Federal or private foundation funds).	1975-1977		$100,000	
o. Special Acquisitions of Wetlands	1975-1985		$5,000,000	Preservation of aquatic animal habitat. Increase in hunter and non-hunter day use
p. Wetlands Inventory (A one year study that could be integrated into ongoing programs. 75% Federal, 25% State funds under Pittman-Robertson. This survey could serve as the base for much of the planning and acquisition recommended under Plan B).	1971-1973		$50,000	

5. Flood Damage Reduction

Plan B provides for a minimum of structural flood protection works. Therefore, local units of government should actively promote and enforce the use of non-structural programs and techniques to reduce flood damages in the basin. Non-structural flood damage reduction programs include land use regulations, flood proofing, permanent evacuation of the flood plain, flood warning systems, and flood insurance. The non-structural flood damage reduction recommendations below are in concert with those for the valley preserve system.

Plan B recommends:

a. That local officials implement and enforce necessary regulations in order to provide flood damage reductions during flooding.

b. That authority be granted to the State to implement and enforce necessary regulations if local officials fail to do so in a reasonable length of time in accordance with the State's Shorelands Protection and Management Act (Act 245, Michigan Public Acts of 1970).

c. That the Congress provide sufficient funds to carry out existing flood forecasting programs and accelerate the flood hazard and flood plain information programs.

d. That the Federal government carefully consider Federal support of programs which call for the implementation of non-structural alternatives as methods of reducing and preventing flood damages in the Grand River basin.

The overall cost to implement necessary non-structural measures in the Grand River basin has not been established.

6. Upstream Watershed and Land Treatment Programs

Plan B provides for six upstream watersheds that need development within the next 10- to 15-years: Upper Maple River, Hayworth Creek, Stoney Creek, Rogue River, Perry Creek and Libhart Creek (see Figure VI-1). These early-action watersheds can be developed when sponsored by qualified units of governemnt. The scope and purpose of these projects will be dependent upon the objectives of the sponsoring organizations and local residents.

Plan B recommends:

a. That structural works of improvement in the 6 watersheds be installed, including: 135.3 miles of multiple-purpose (flood prevention and drainage) channel work; one single-purpose flood prevention structure; and two multiple-purpose structures as described on pages V-273 thru V-278.

The installation cost of these proposed structural measures is estimated at $18,029,300. Total average annual benefits are estimated at $2,726,600. Total average annual costs are $1,218,459. The resulting benefit-cost ratio is 2.24:1. Under provisions of the Watershed Protection and Flood Prevention Act (PL 83-566, as amended) qualified sponsors would be eligible for technical assistance for the design, and cost-sharing assistance for the construction of these structural measures.

b. That a 10-year accelerated land treatment program in the 6 upstream watersheds and in the remainder of the basin be carried out. This program would provide adequate treatment for 88,000 acres in the 6 watersheds at an estimated cost of $4,869,600. Land treatment would be provided to another 356,200 acres in the remainder of the basin at an estimated cost of $19,773,200. The total cost of the accelerated land treatment program is estimated at $24,643,000. The treatment program would reduce excessive runoff, erosion, and sedimentation, and would enhance environmental quality in the Grand River basin.

c. That technical assistance programs for urban areas be instituted in order to protect soil and water resources and to provide opportunity for man to live in harmony with his natural environment. The programs would include:

(1) A 10-year urban soil and water conservation program to meet problems of poor land use and erosion in urban areas throughout the basin.

The cost of this portion of the technical assistance program is estimated at $800,000. It would be implemented through the Soil Conservation Districts in cooperation with the Soil Conservation Service, USDA.

(2) A 10-year urban and community forestry assistance program with emphasis on the Grand Rapids and Lansing areas. The cost of the forestry program is estimated to be $600,000. The Forest Service, USDA, would be assigned leadership in this program in cooperation with the Michigan Department of Natural Resources.

The goals of the urban technical assistance program may be achieved through proper land use planning designed to reduce soil erosion, help maintain water quality, reduce flood damages, improve vegetative cover, and enhance natural beauty. This program will provide assistance to planning boards, community leaders, and developers in formulating and implementing effective land use plans.

d. That an accelerated program be instituted to complete the soil surveys throughout the basin by 1985. A total of 1,172,800 acres would be surveyed through the National Cooperative Soil Survey, at an estimated total cost of $751,000.

e. That a 15-year comprehensive program for water quality monitoring of agricultural pollutants in upstream areas be instituted at an estimated cost of $630,000. The water quality monitoring program would be implemented by the Soil Conservation Service and other USDA agencies in cooperation with the U.S. Environmental Protection Agency and the Michigan Water Resources Commission. The cost-sharing arrangement would consist of 75 percent Federal and 25 percent non-Federal. This program would monitor sediment, bacteria, nitrates, phosphates, chlorides, and other pollutants discharged as a result of agricultural production processes for the 15-year period. In addition, comprehensive surveys of soil and land use conditions, fertilizer and pesticide application, and livestock population would be conducted in areas upstream from the monitoring points. This will provide information on land use and management conditions as they affect quantities of various pollutants carried in the surface waters.

f. That the accelerated land treatment program be continued to meet post 1985 needs. Through this program, it is estimated that 85 percent of the land treatment needs would be satisfied by the year 2020. One portion of this

program would be applied within the 6 early-action watersheds. The other portion would be applied in the remainder of the basin.

g. That the technical assistance program for urban areas be continued to meet post 1985 needs. Results of accomplishments during the Early Action Program would be reviewed in order to prepare a detailed program and budget estimates.

h. That a review and evaluation of the cooperative agricultural water quality monitoring program be conducted at the close of the 15-year period. Data collected and analyses completed to that date would be reviewed to determine future program activities and funding levels.

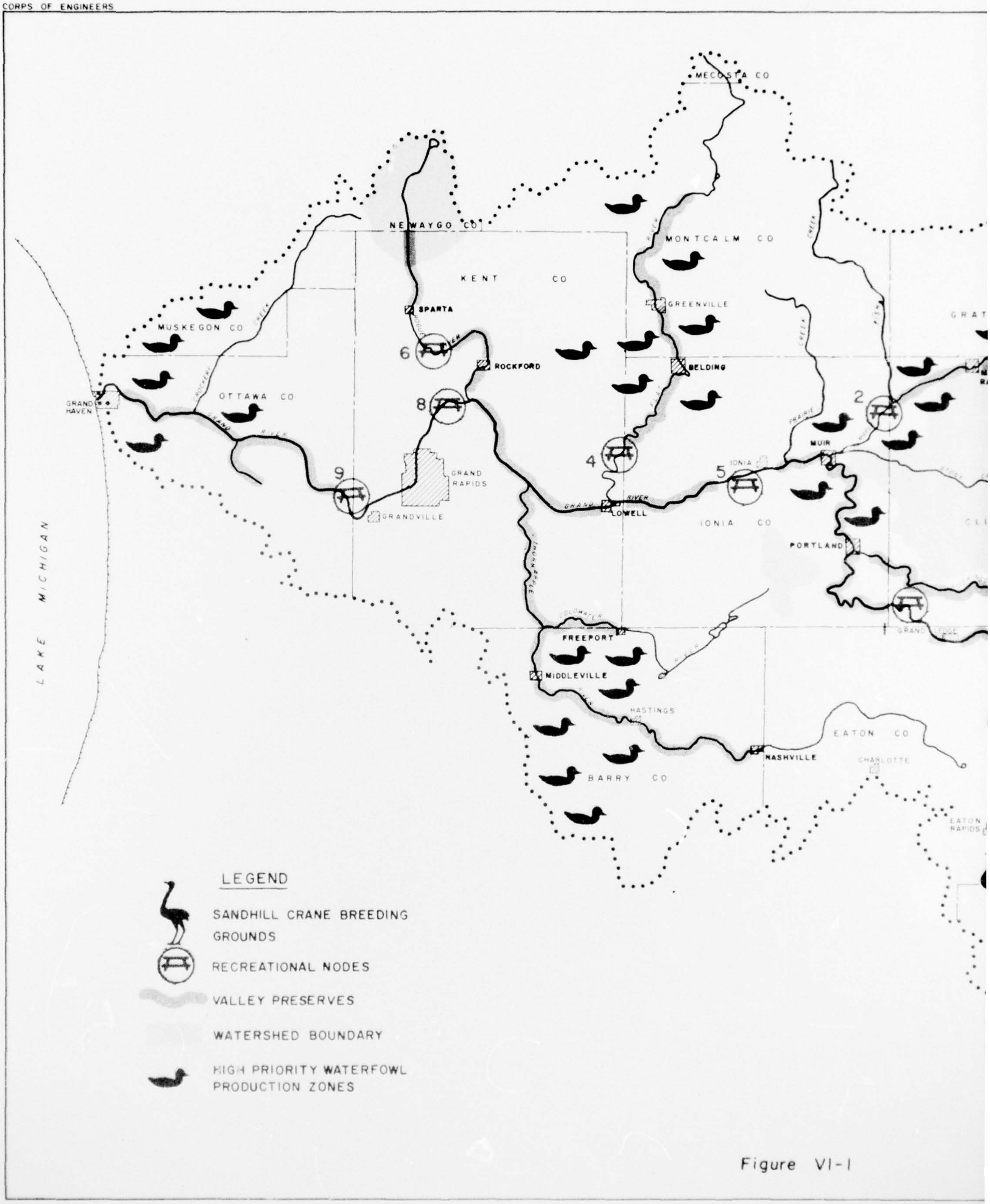
7. Electric Power

The Grand River basin is currently an importer of electric energy and is expected to continue to be within the time frame of this study. Additional electric power demands in the basin can be met by drawing from sources located outside of the basin. Consequently, Plan B includes no provisions for increasing the overall capacity of electric power plants in the Grand River basin to meet future needs.

8. Navigation

The existing and future utilization of the Grand River in the interest of recreational and commercial navigation is being investigated. An on-going study authorized by a House Public Works Committee Resolution adopted 1 March 1950, will investigate the need for improving the Grand River in regard to commercial navigation. Another on-going study authorized by a House Public Works Committee Resolution adopted 9 April 1957, will cover the recreation boating aspect of navigation on the Grand River.

Preliminary investigations indicate that further improvement of Grand Haven Harbor and the lower reach of the Grand River up to the Bass River for commercial navigation appear to have some economic justification. Thus, providing appropriate studies are coordinated to determine economic justification, the extent of Federal interest and the applicability of cost-sharing, and other factors, Plan B indorses provisions for improving the Grand River in regard to commercial and recreational navigation as described on pages V-287 and V-288.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KENT CO
MUSKEGON CO
OTTAWA CO
GRAND HAVEN
SPARTA
ROCKFORD
GREENVILLE
BELDING
GRAND RAPIDS
GRANDVILLE
LOWELL
IONIA
IONIA CO
MUIR
PORTLAND
GRAND RIVER
LAKE MICHIGAN
FREEPORT
MIDDLEVILLE
HASTINGS
NASHVILLE
EATON CO
CHARLOTTE
BARRY CO
EATON RAPIDS
GRAND LEDGE
1
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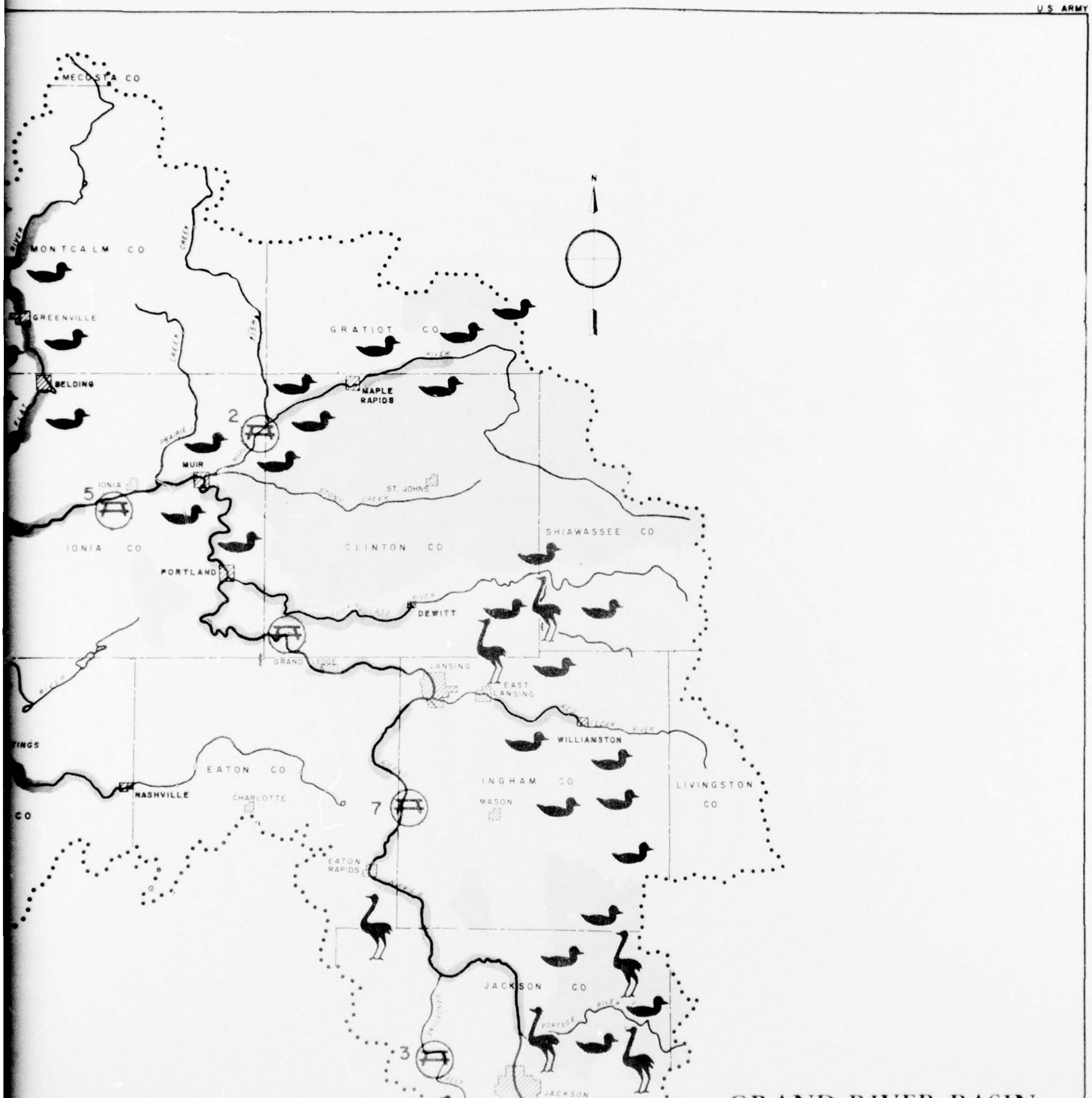
9
LEGEND
SANDHILL CRANE BREEDING GROUNDS
RECREATIONAL NODES
VALLEY PRESERVES
WATERSHED BOUNDARY
HIGH PRIORITY WATERFOWL PRODUCTION ZONES

Figure VI-1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CLINTON CO
SHIAWASSEE CO
DEWITT
GRAND LEDGE
LANSING
EAST LANSING
WILLIAMSTON
EATON CO
NASHVILLE
CHARLOTTE
INGHAM CO
MASON
LIVINGSTON CO
EATON RAPIDS
JACKSON CO
JACKSON
MICHIGAN CENTER
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5
7
3
GRAND RIVER BASIN, MICHIGAN
RECOMMENDED PLAN

Figure VI-1

TABLE VI-2
GRAND RIVER BASIN STUDY
COST SHARING OF EARLY ACTION PROGRAMS

PROGRAM	PERIOD	COST	FEDERAL	NON-FEDERAL
1. Water Quality				
a. Water Quality Management Plan	1970-1985	$150,000,000 (50,000,000 for ea. 5-yr period)	$112,500,000 (37,500,000 for ea. 5-yr. period)	$37,500,000 ($12,500,000 for ea. 5-yr. period)
b. Applied Research Program	1975-1984	2,000,000 (200,000 yrly)	2,000,000 (200,000 yrly)	0
2. Valley Preservation	1975-1984	22,500,000 (2,250,000 yrly)	11,250,000 (1,125,000 yrly)	11,250,000 (1,125,000 yrly)
3. Recreation	1975-1984	48,216,000 (4,821,600 yrly)	24,108,000 (2,410,800 yrly)	24,108,000 (2,410,000 yrly)
4. Fish and Wildlife				
a. Ongoing Acquisition	1970-1975 (5-yr. period)	663,000 (132,600 yrly)	331,500 (66,300 yrly)	331,500 (66,300 yrly)
b. Goal Acreage Acquisition	1970-1985 (7 yr. period)	14,000,000 (2,000,000 yrly)	7,000,000 (1,000,000 yrly)	7,000,000 (1,000,000 yrly)
c. Ongoing Fishery	1971-1975	76,000	57,000	19,000
d. Fish Passage and Dam Removal	1973-1985	335,000 for fish passage 515,000 for dam removal	257,500	257,500
e. Water Bank Act (P.L. 91-559)	1973-1985	600,000	600,000	0
f. Sandhill Crane Study	1975-1977	100,000	100,000	0

TABLE VI-2 (Cont'd)
GRAND RIVER BASIN STUDY
COST SHARING OF EARLY ACTION PROGRAMS

PROGRAM	PERIOD	COST	FEDERAL	NON FEDERAL
4. Fish and Wildlife				
g. Special Acquisition of Wetlands	1975-1985	$5,000,000 (500,000 yrly)	$2,500,000 (250,000 yrly)	$2,500,000 (250,000 yrly)
h. Wetlands Inventory	1971-1973	50,000	37,500	12,500
5. Upstream Watershed Program (Structural Works of Improvement in 7 Upstream Watersheds	1970-1985 (10-15 yrs.)	$18,029,300	$12,024,400	$6,004,900
6. Land Treatment-Accelerated	(10-yr. program)			
a. Six Upstream Watersheds (1) Installation	1970-1985	$4,032,800	0	$4,032,800**
(2) Technical Assistance	1970-1985	837,000	812,700	24,300
b. Remainder of Basin (Rural) (1) Installation	1970-1985	16,889,100	0	16,889,100**
(2) Technical Assistance	1970-1985	2,884,200	2,726,200	158,000
c. Environmental Enhancement in Urban and Built-up areas (1) Technical Assistance	1970-1985	1,400,000	1,400,000	0
d. Accelerated Soil Survey	1970-1985	751,000	751,000	0
7. Water Quality Monitoring of Agricultural Pollutants in Upstream areas	1985-2000 (15-yr. Program)	$630,000	$472,500	$157,500
Total Cost		$289,173,400	$178,455,800	$110,245,100

**Does not reflect Federal cost-sharing assistance which may be available for installation of conservation measures through various programs.

SECTION VII
IMPLEMENTATION

The State of Michigan and local governmental entities have the basic responsibility for the initiation, implementation, operation and maintenance of the recommended programs of Plan B. Even in those areas where a Federal agency normally performs the detailed planning and construction, the impetus for these activities must originate with those benefited by the programs and facilities.

Data for projects and programs included in the 10- to 15-year plan are considered to be of the scope required by the applicable agencies for making decisions concerning project selections and engineering and economic feasibility. However, the data must be refined by detailed planning and design studies necessary to establish final design features of the projects and form a basis for final construction plans and specifications.

Those projects and programs in the 10- to 15-year plan in which a Federal agency has primary responsibility in planning and assisting will be presented in an agency report for appropriate implementation. These programs would be implemented when funds are available and the required local cooperation is fulfilled.

Individuals, private businesses, and local developmental groups should be encouraged to take timely steps to implement the non-governmental features of the plan which are necessary for realization of its full benefit.

The Federal share of the cost of the programs included in the comprehensive plan would be provided in accordance with laws and regulations applicable at the time of financing. Where Federal assistance is needed for initial financing of the non-Federal share of project and program costs, reimbursement to the Federal government would be made by non-Federal interests in accordance with laws and regulations applicable at that time.